Pinpointing Habitability in Nili Patera's Hydrothermal Field

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Mars 2020 Landing Site Meeting

May 15, 2014

When Mars became a place

Christiaan Huygens - 1659
First Drawing of Mars

Christiaan Huygens

When Mars became a place

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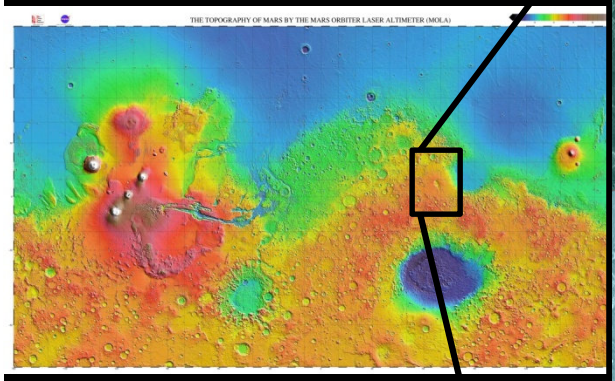
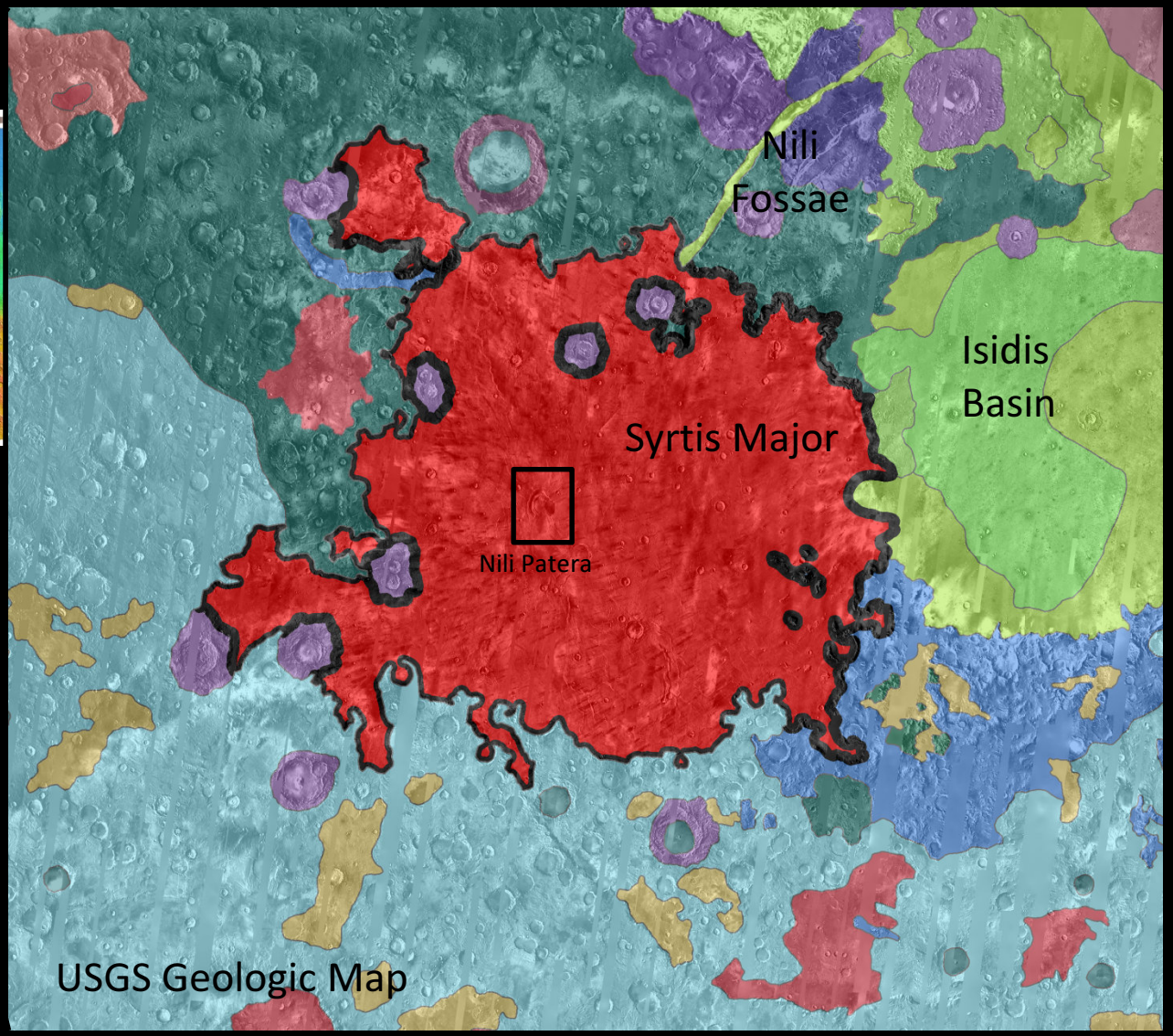
First Drawing of Mars

Christiaan Huygens

Syrtis Major Context





Science Objectives

- **Threshold Geological Criteria:**
  - Presence of hydrothermal sediments
  - Presence of aqueous phases in outcrop
  - Noachian/Early Hesperian age
  - Presence of igneous rocks
  - Not a Special Region
- **Potential Qualifying Geological Criteria:**
  - Standing bodies of water and/or fluvial activity
  - Assemblages of secondary minerals of any age.
  - Presence of former water ice, glacial activity or its deposits.
  - Igneous rocks of Noachian age/megabreccia.
  - Volcanic unit of Hesperian or Amazonian
  - Probability of samples of opportunity
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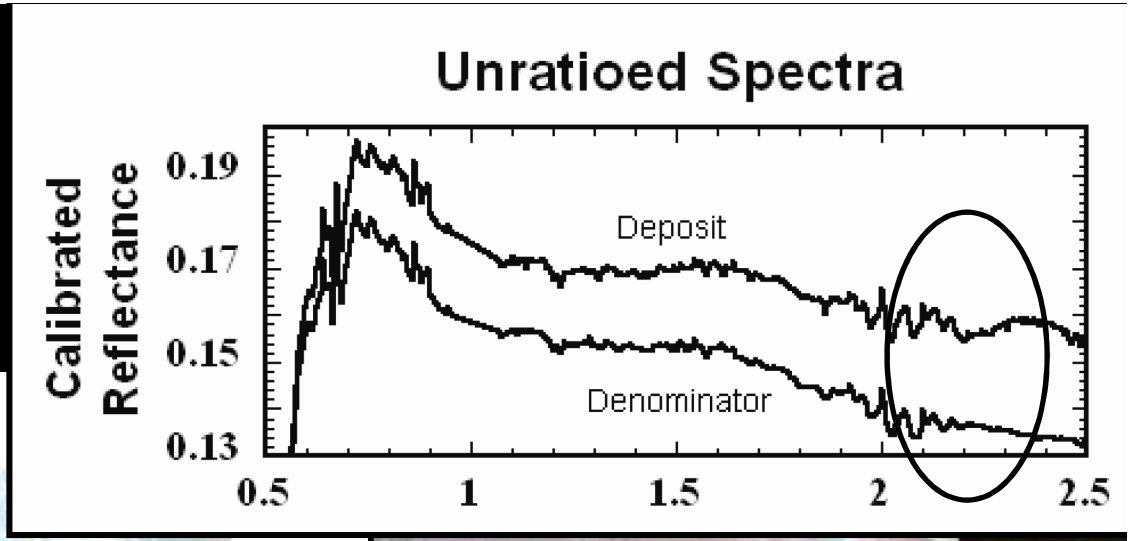
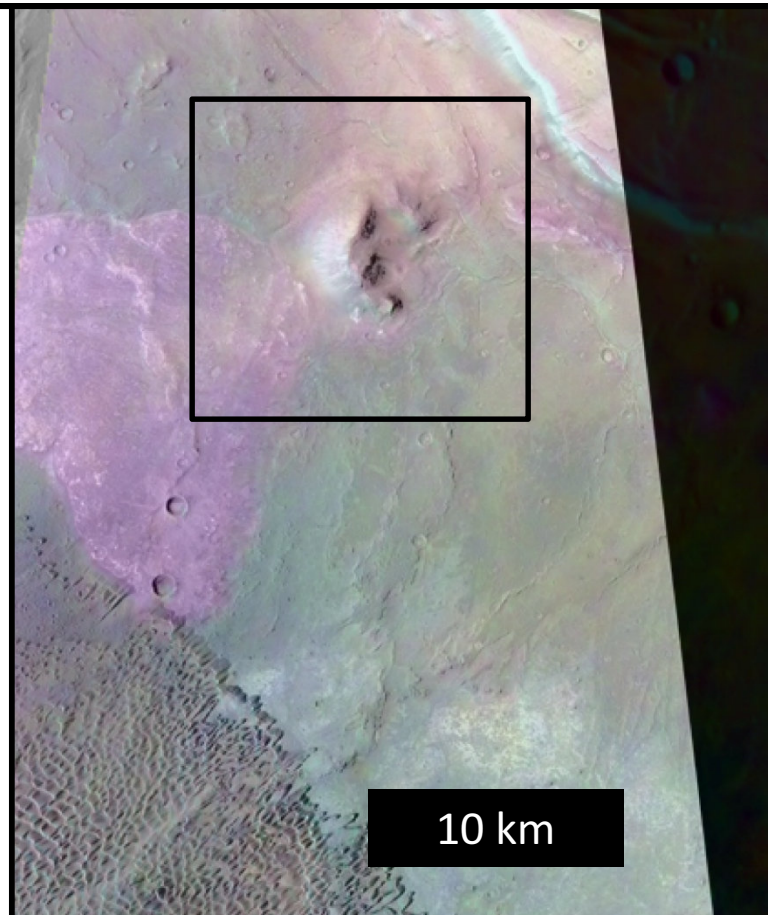
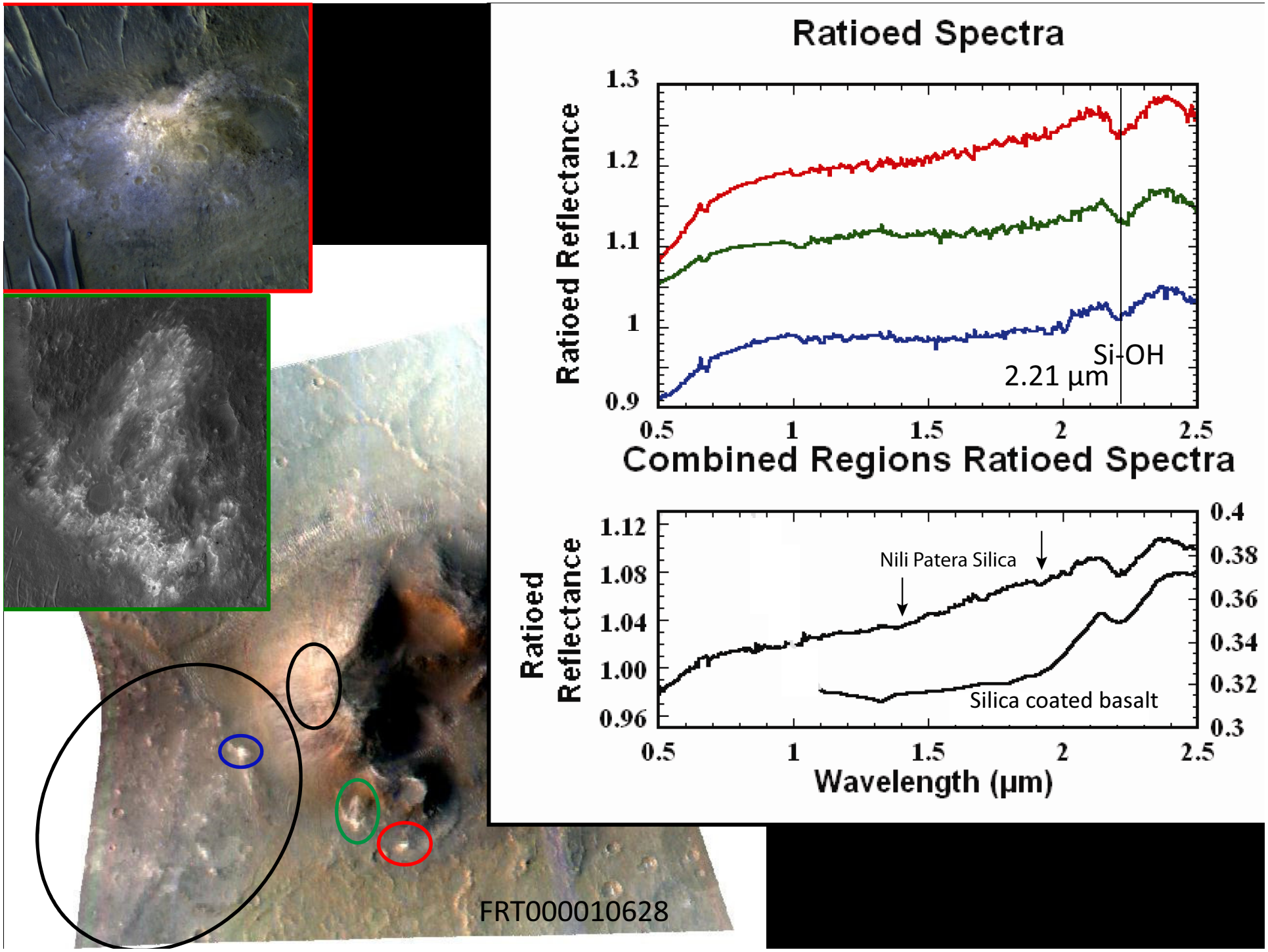
Testable Hypotheses in Nili Patera

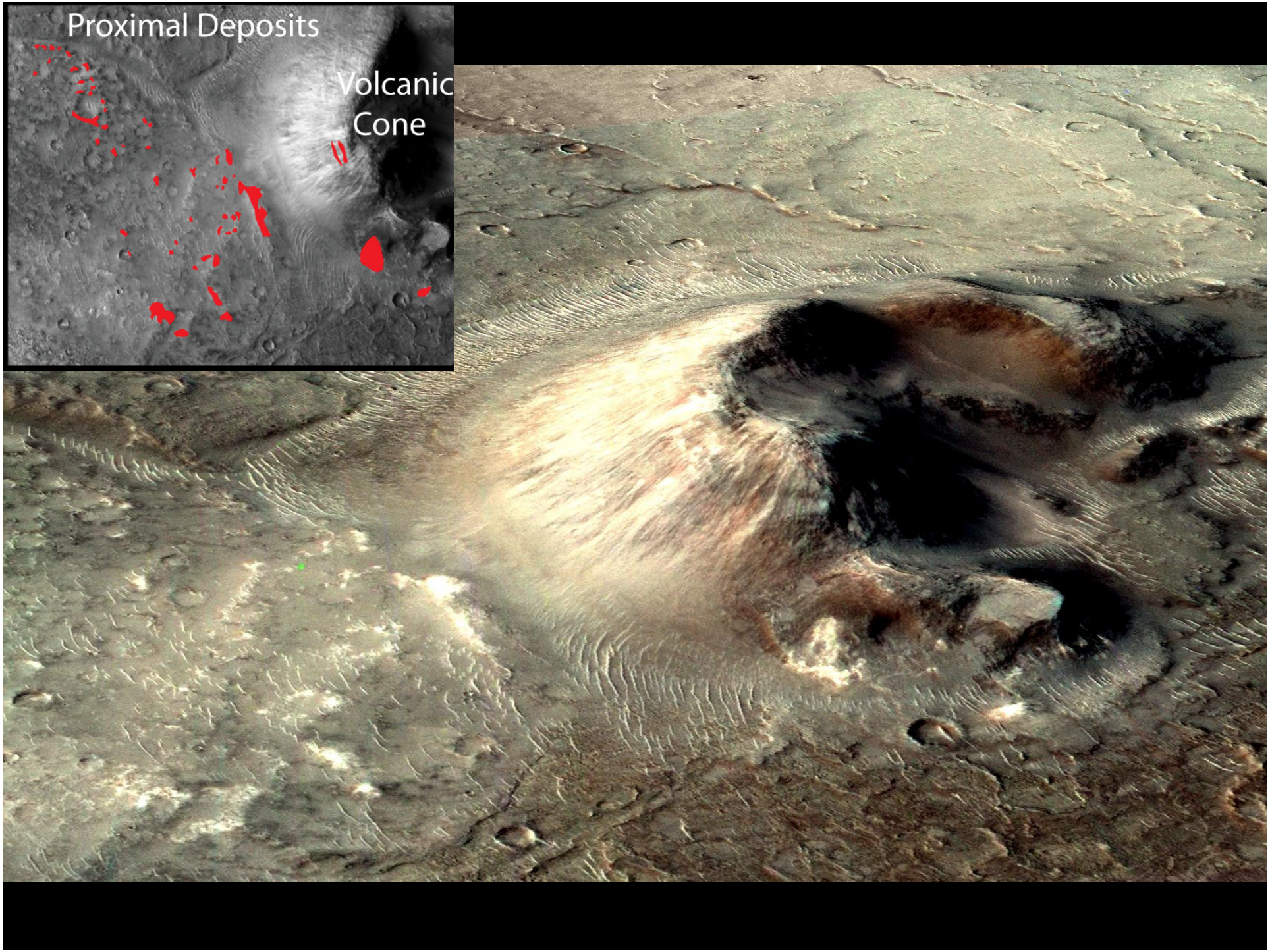
- Silica Deposits
  - Formation?
    - Alkaline or Acidic?
    - Magmatic water or ground water?
    - Hot springs, Geysers, Fumaroles?
    - Duration?
  - Habitability?
    - This system?
    - Habitable conduit to deep subsurface?
  - Ever Inhabited?
- Volcanics
  - What drove the Early Hesperian volcanic pulse?
  - Calibrate crater counting chronology?
  - Evolved or Explosive volcanism?
  - Basalt remote sensing calibration?
  - Mantle history from potential xenoliths?

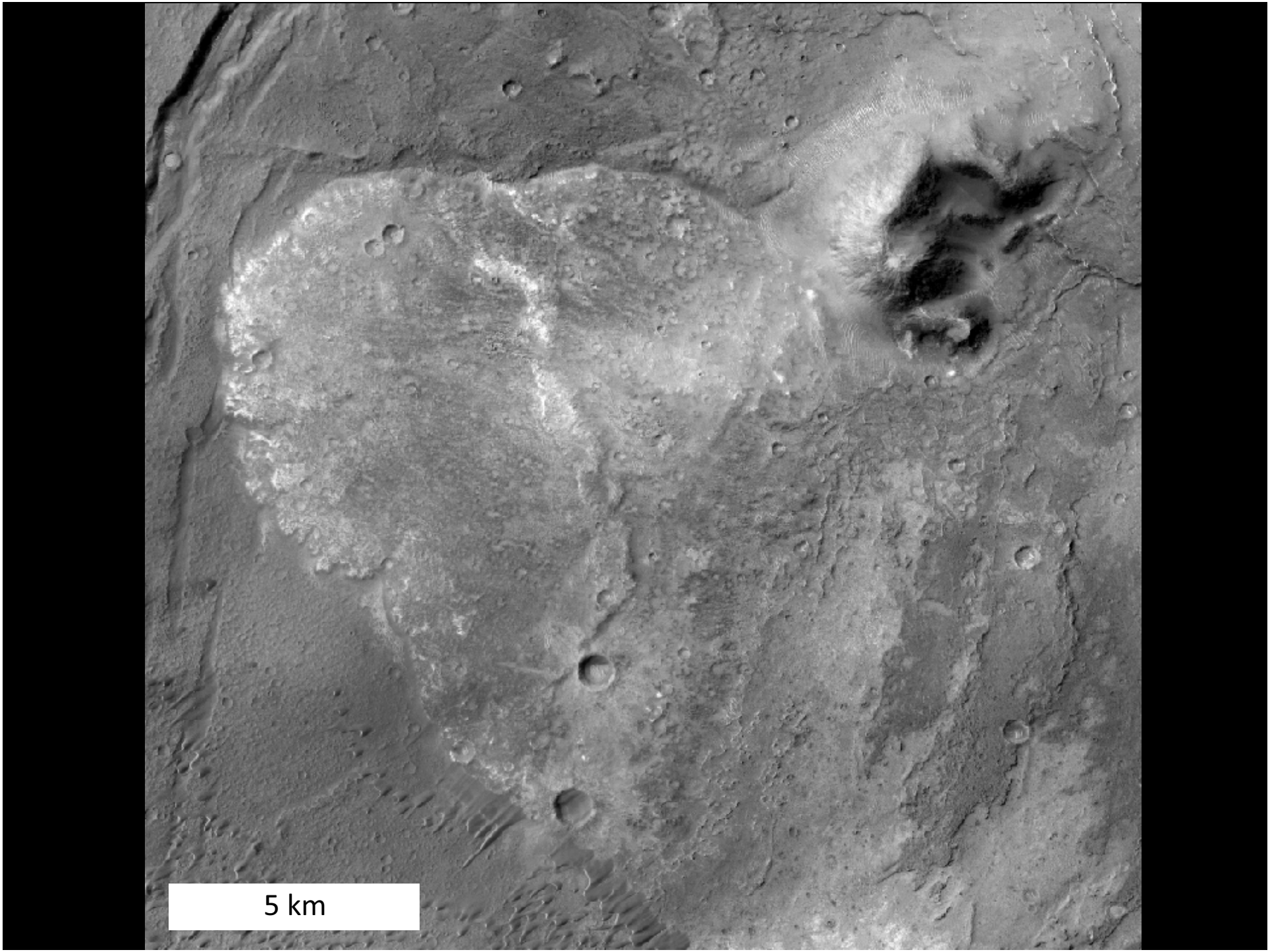
Calibrated CRISM Spectra

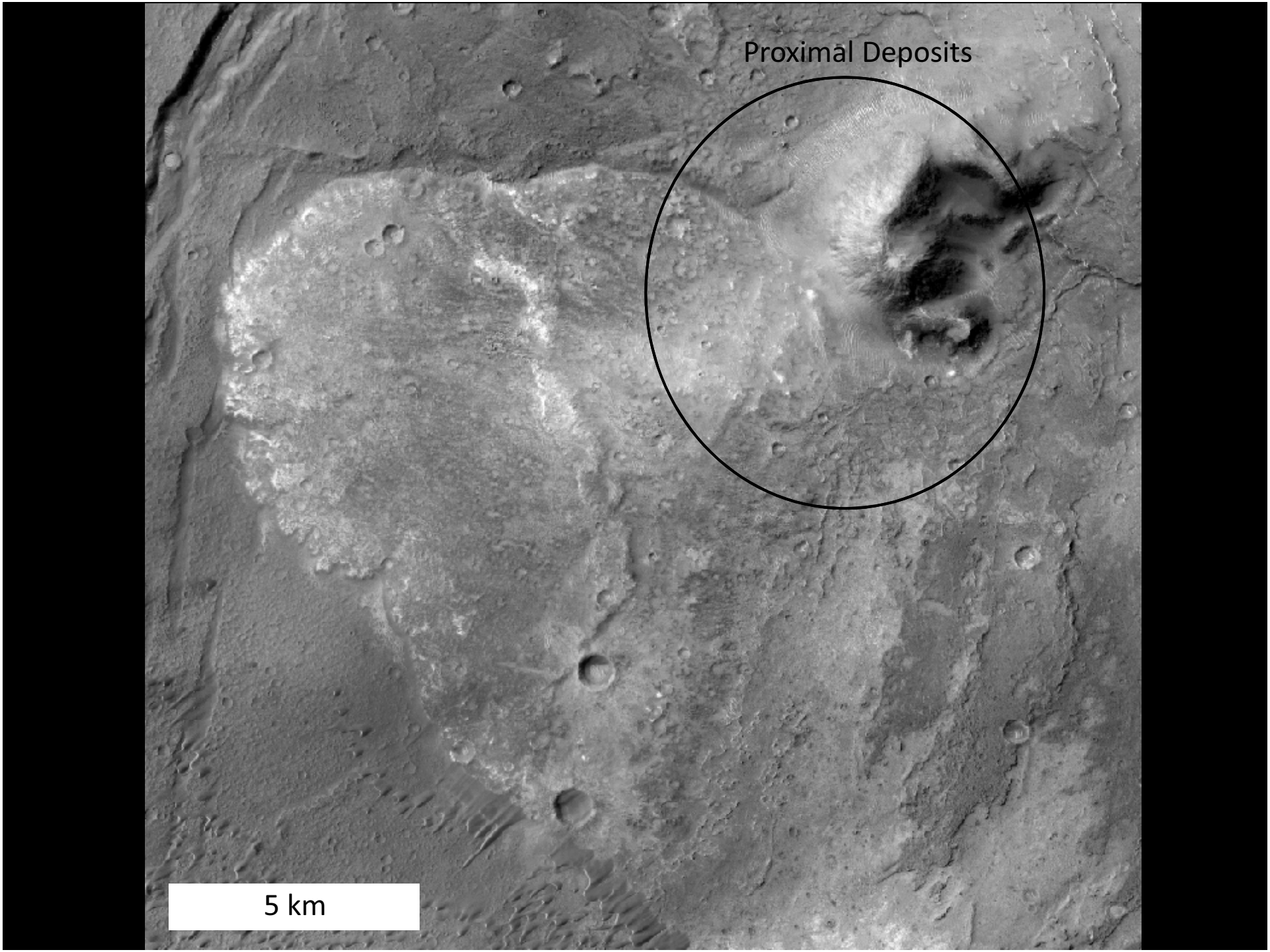


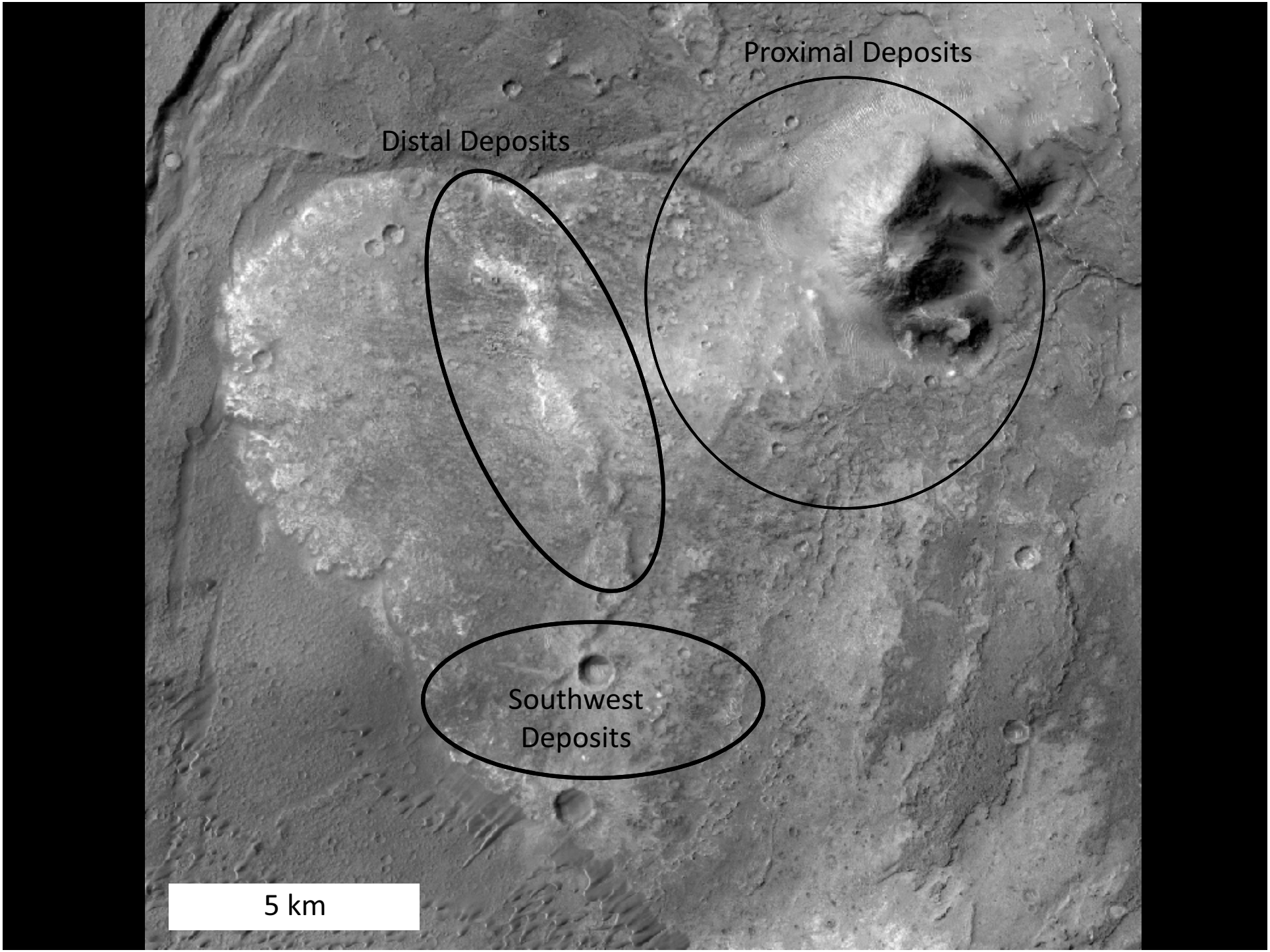


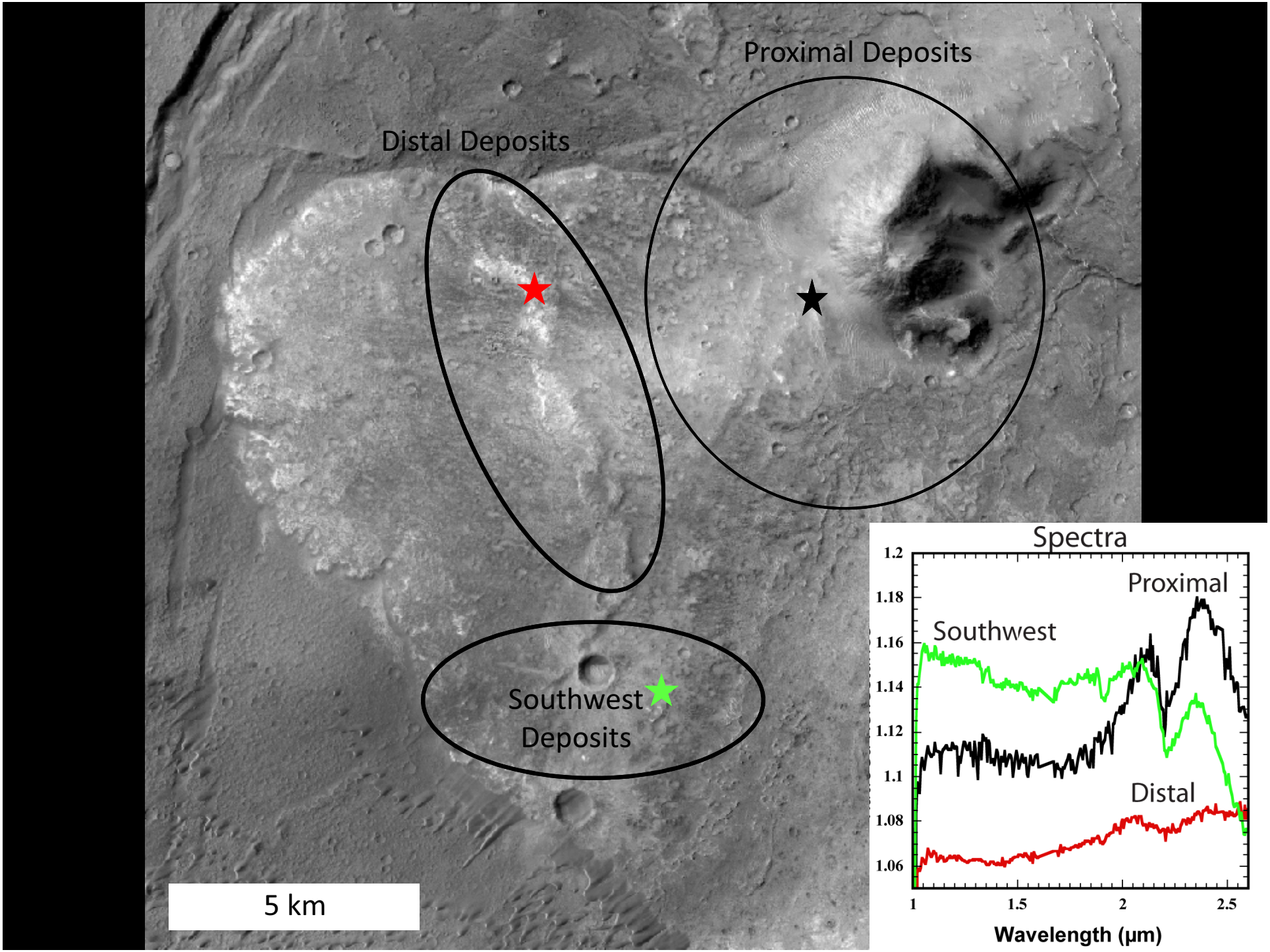

Ratioed Spectra
Ratioed Reflectance
1.3
1.2
1.1
1
0.9
0.5
1
1.5
2
2.5
Si-OH
2.21 µm
Combined Regions Ratioed Spectra
Ratioed Reflectance
1.12
1.08
1.04
1.00
0.96
0.4
0.38
0.36
0.34
0.32
0.3
Nili Patera Silica
Silica coated basalt
0.5
1
1.5
2
2.5
Wavelength (µm)
FRT000010628

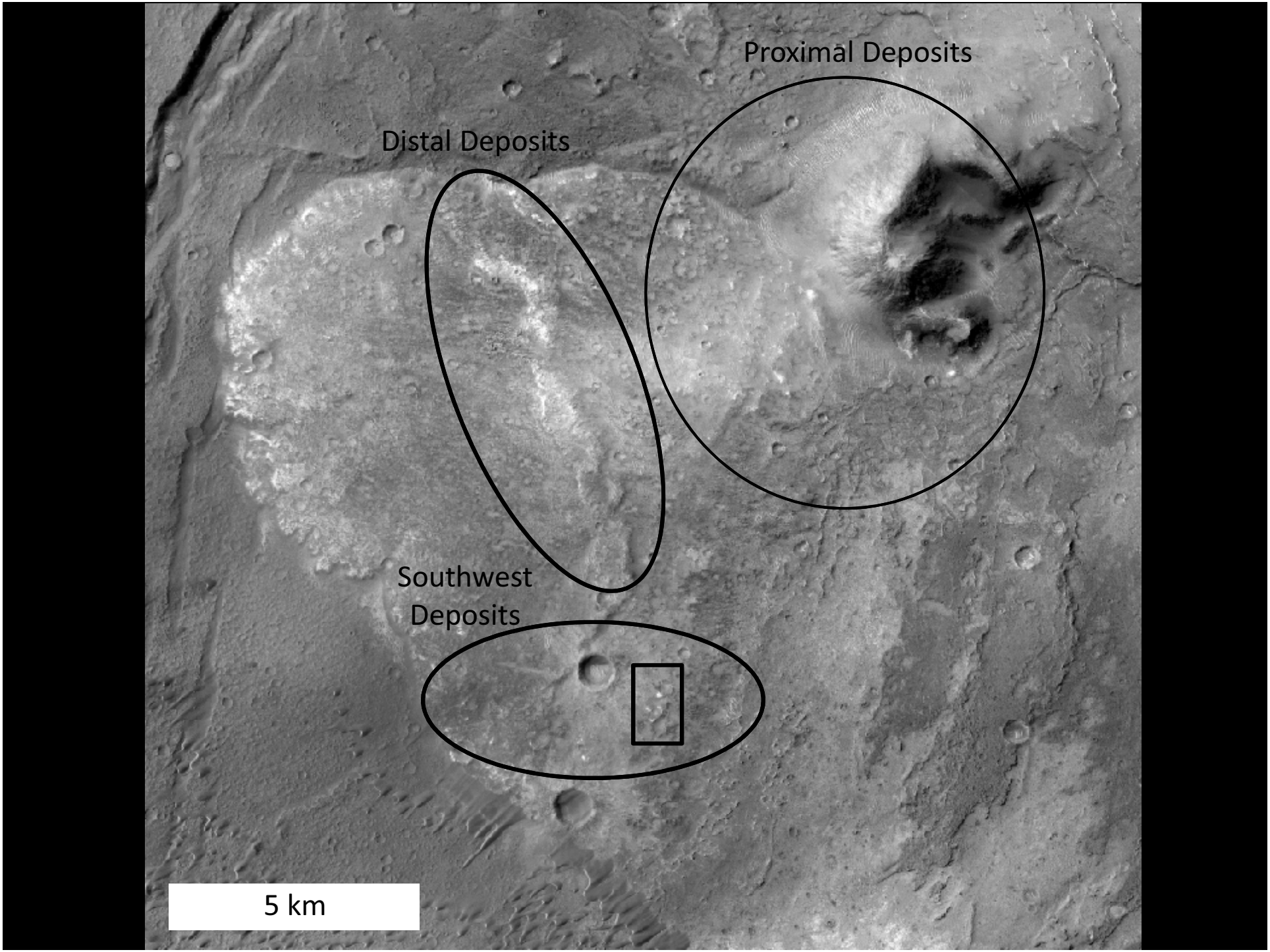

Proximal Deposits
Volcanic Cone

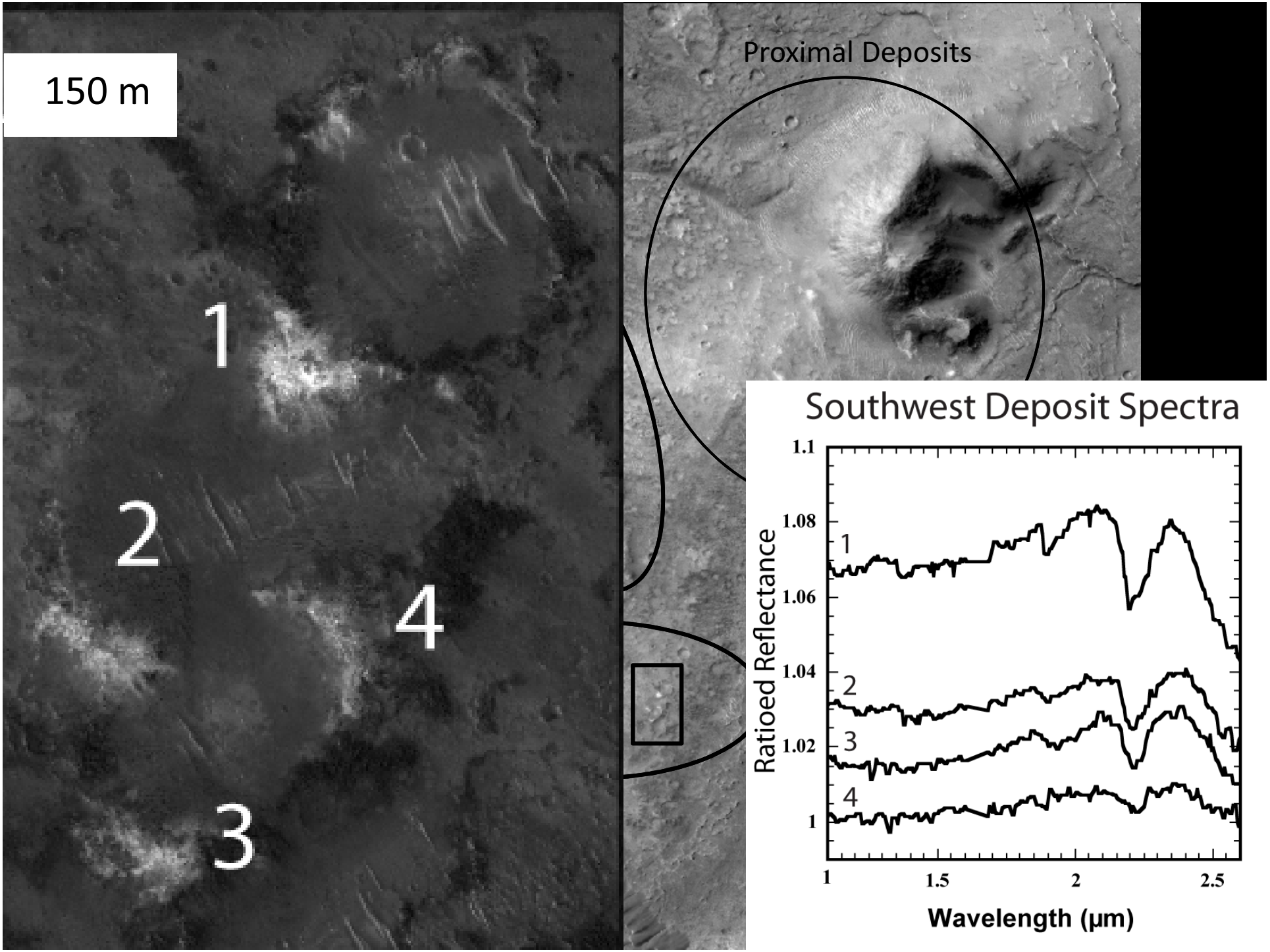

5 km

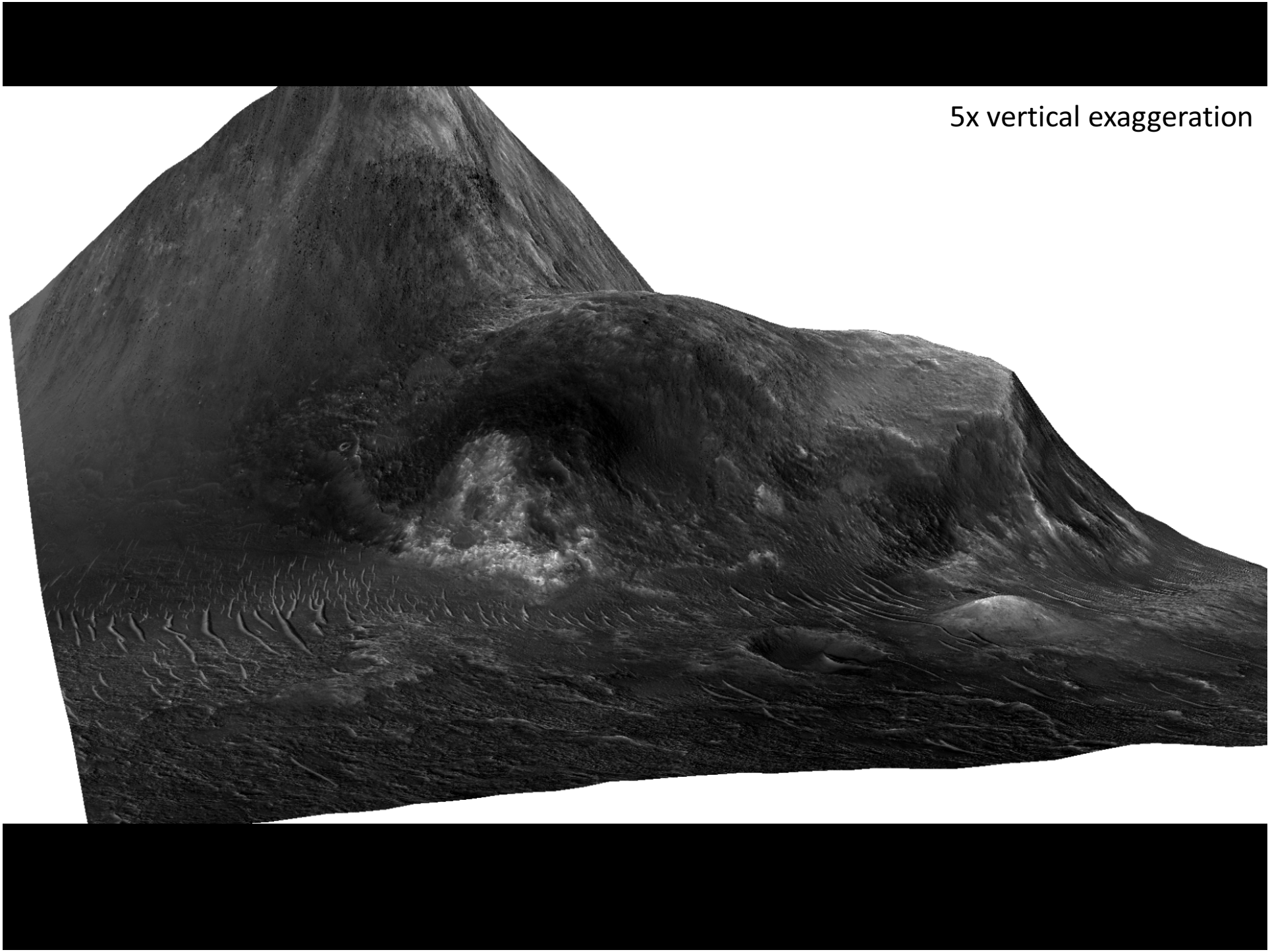

Proximal Deposits
5 km

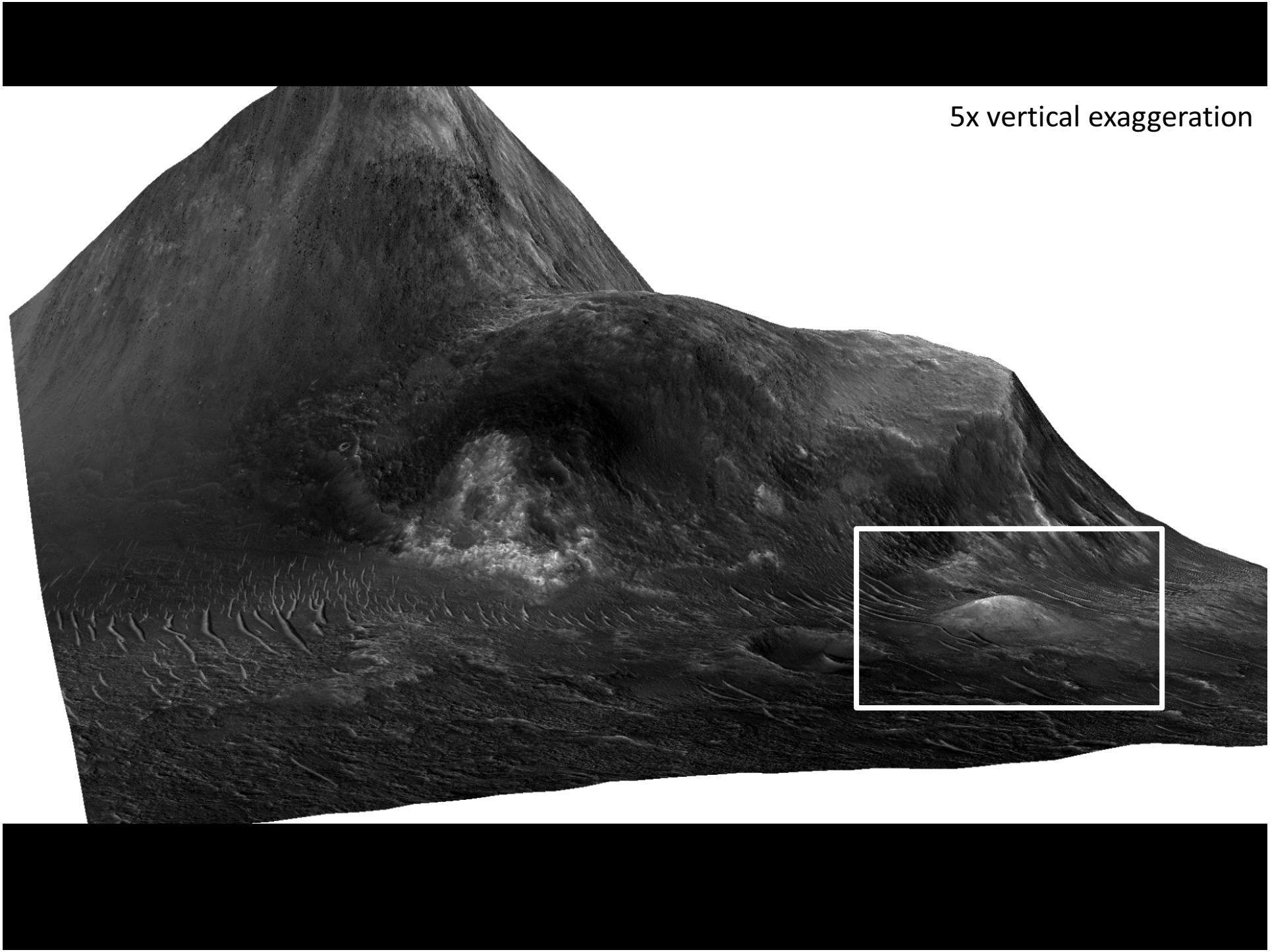

Proximal Deposits
Distal Deposits
Southwest
Deposits
5 km


Proximal Deposits
Distal Deposits
Southwest
Deposits
5 km
Spectra
Proximal
Southwest
Distal
1.2
1.18
1.16
1.14
1.12
1.1
1.08
1.06
1
1.5
2
2.5
Wavelength (μm)


Proximal Deposits
Distal Deposits
Southwest
Deposits
5 km


150 m
1
2
3
4
Proximal Deposits
Southwest Deposit Spectra
Ratioed Reflectance
1.1
1.08
1.06
1.04
1.02
1
1
1.5
2
2.5
Wavelength (μm)


5x vertical exaggeration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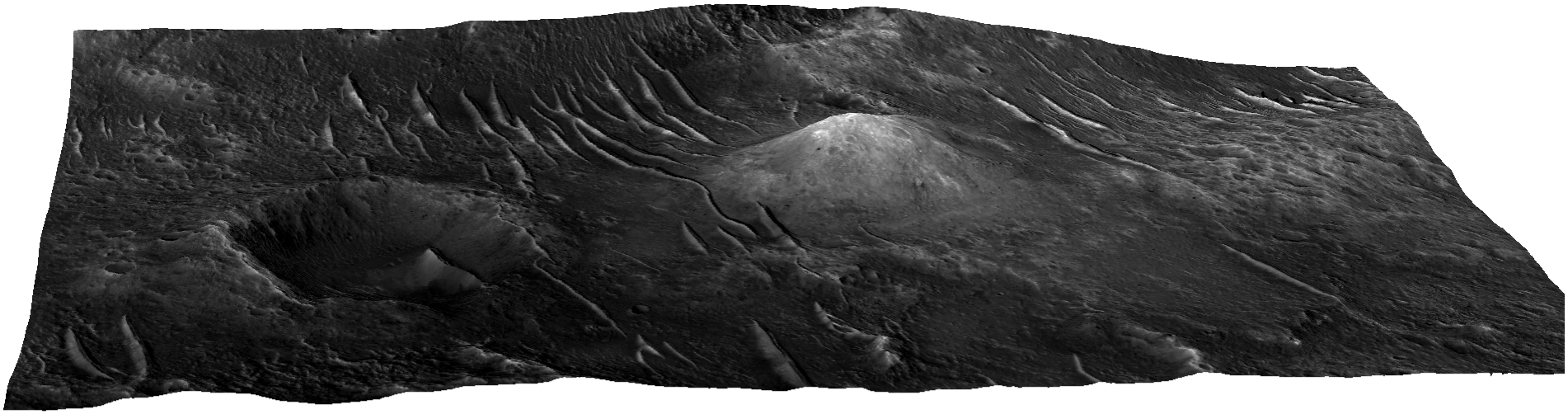
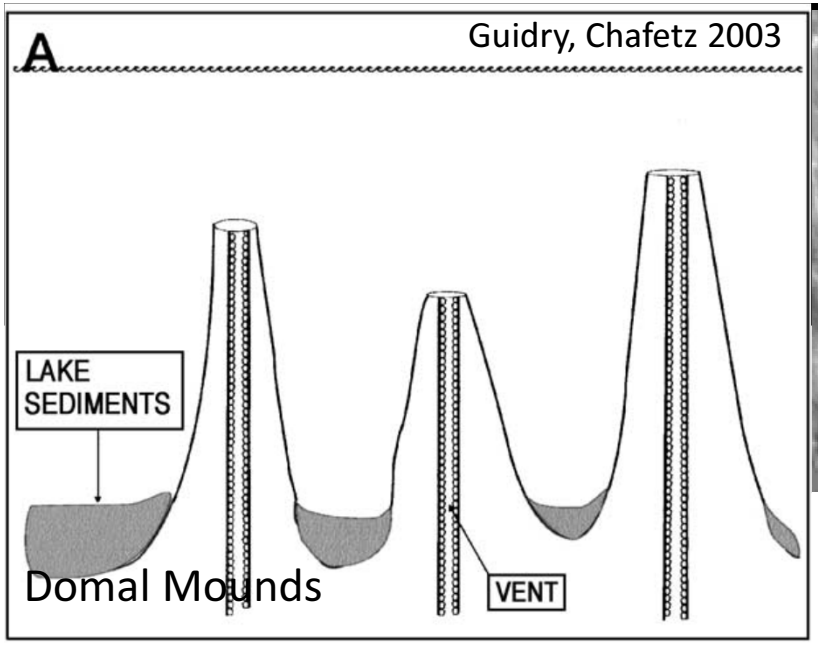
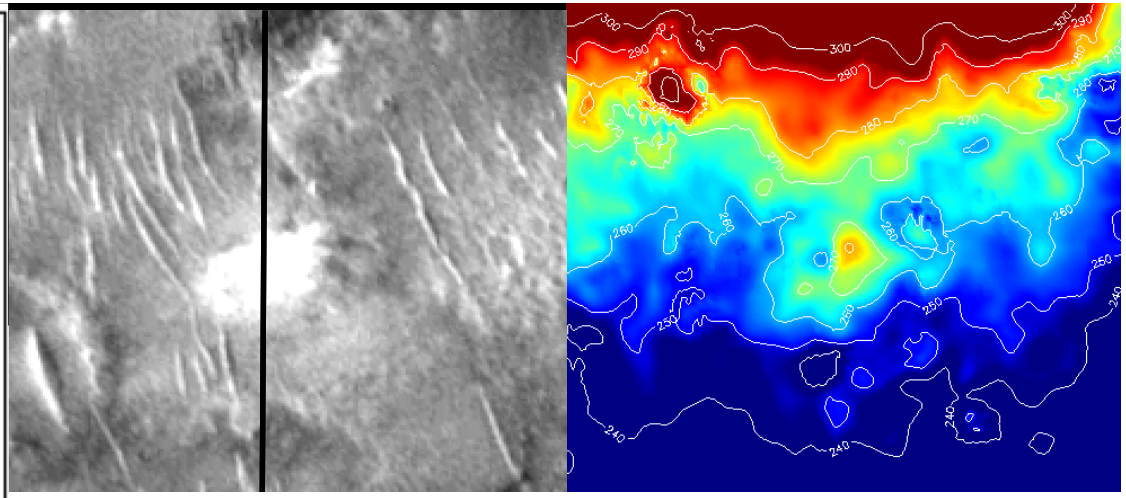
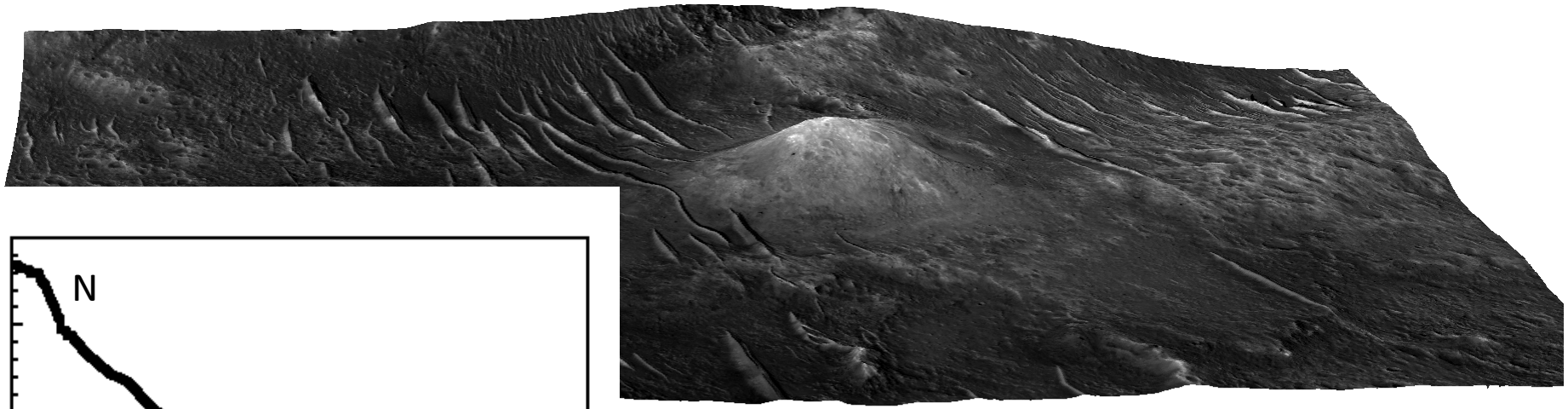
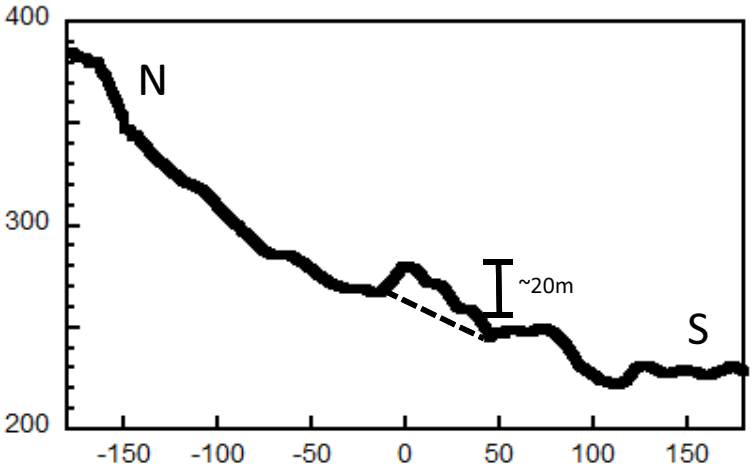



A
Guidry, Chafetz 2003
LAKE SEDIMENTS
VENT
Domal Mounds



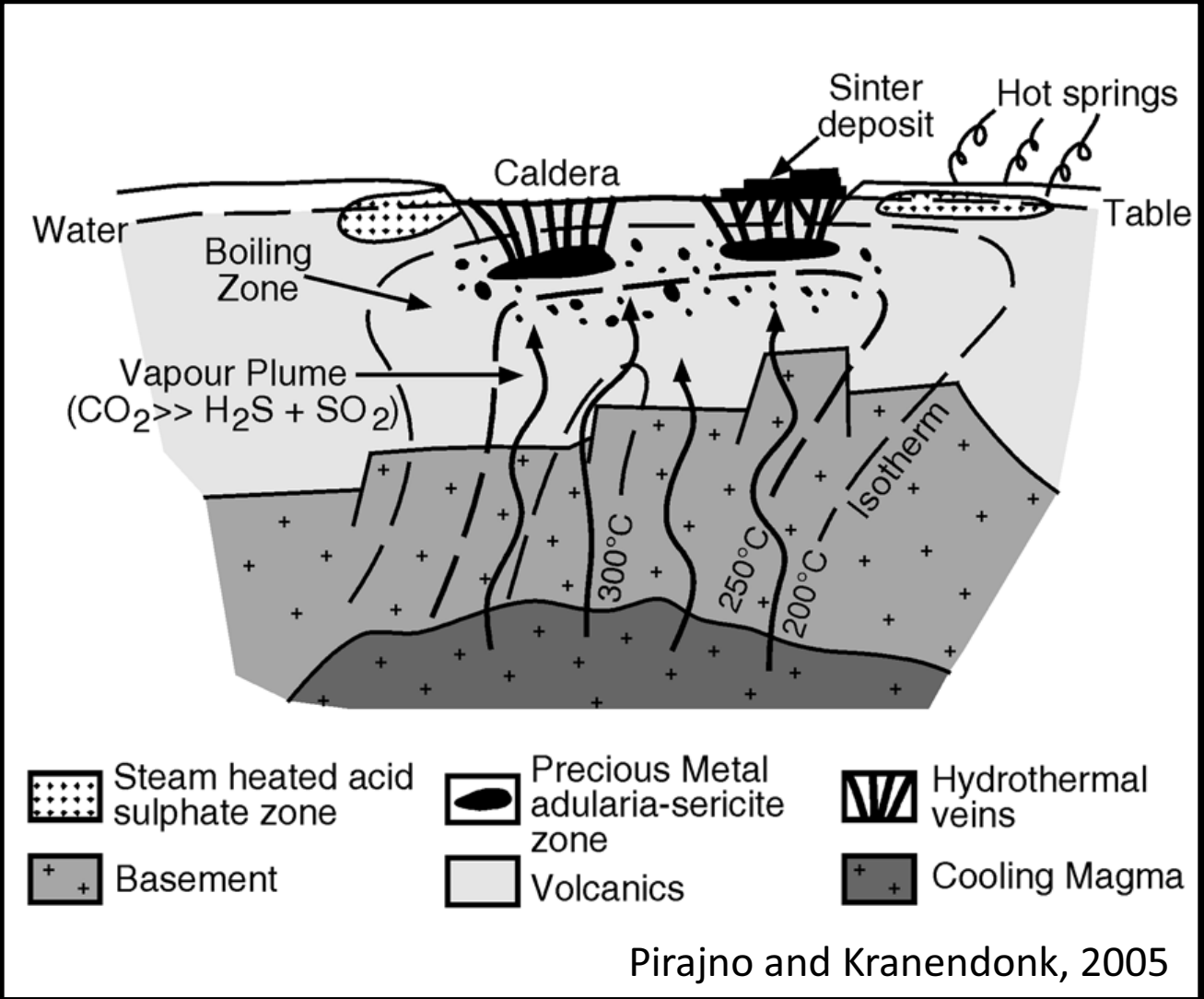



400
300
200
N
S
~20m
-150
-100
-50
0
50
100
150

Pinpointing Habitability

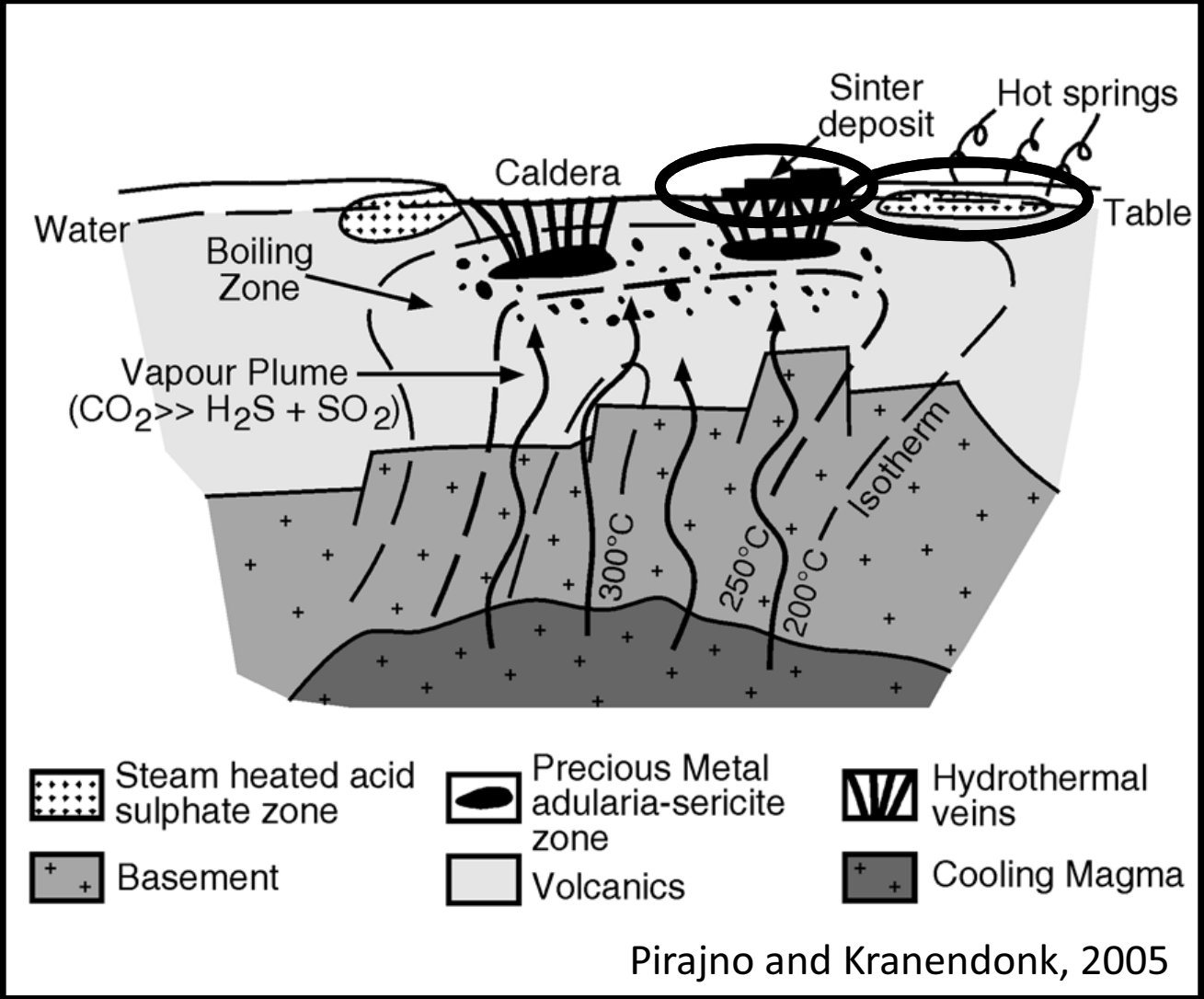
Formation environment
- Caldera Setting
  - Neutral to Alkaline
  - Hot Springs
  - Silica sinters
  - Low-suflidation
  - Epithermal

In contrast to:
- Acid-Sulfate
  - High-sulfidation



Pirajno and Kranendonk, 2005

Pinpointing Habitability



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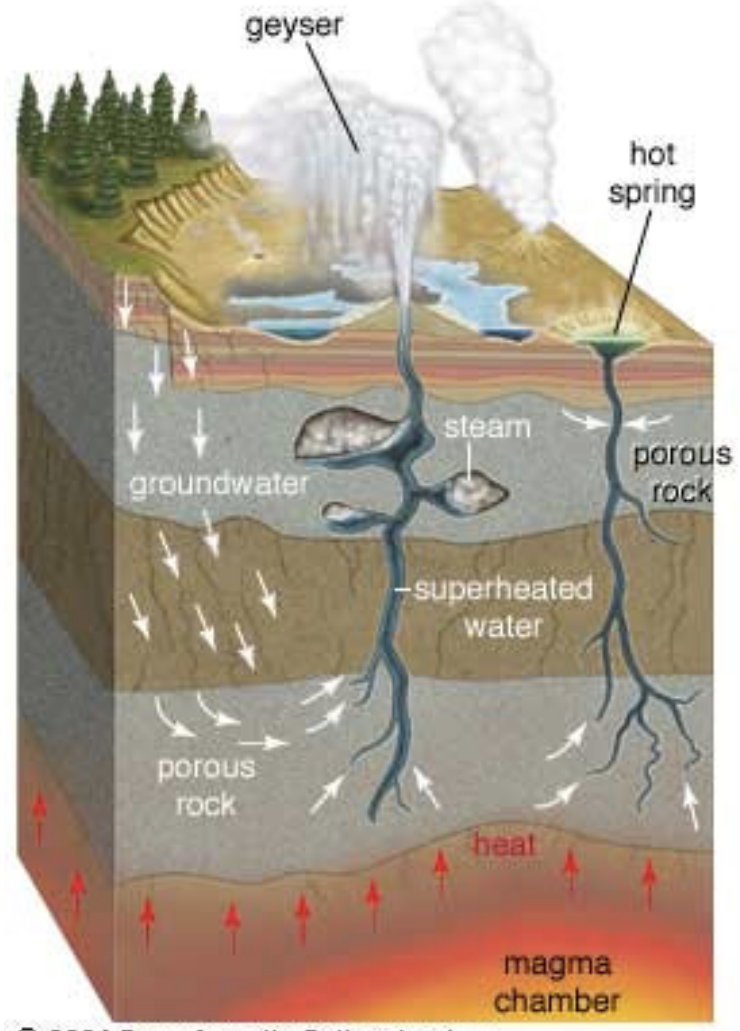

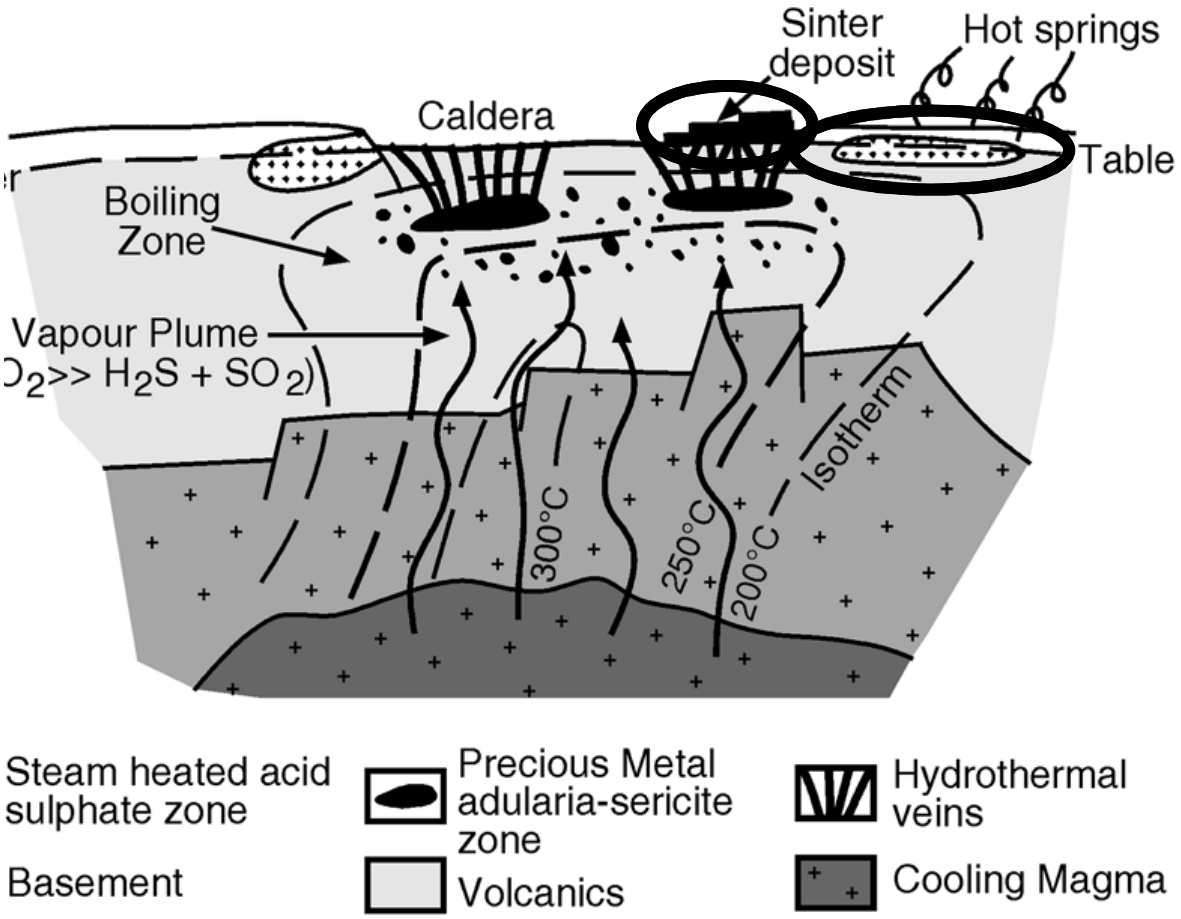

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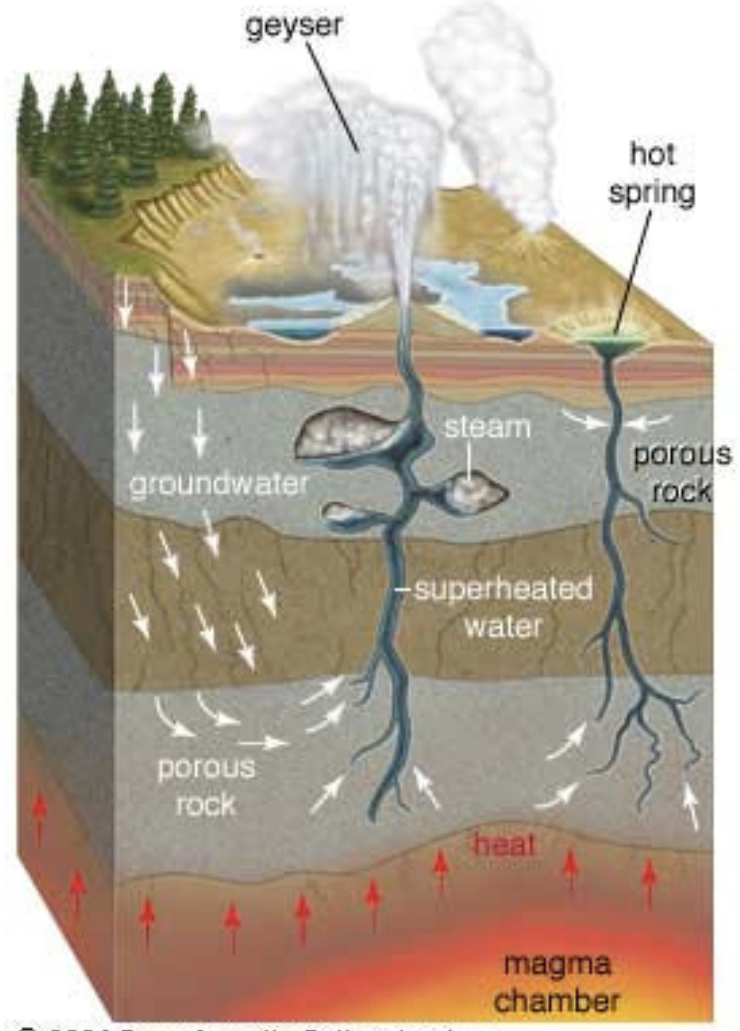

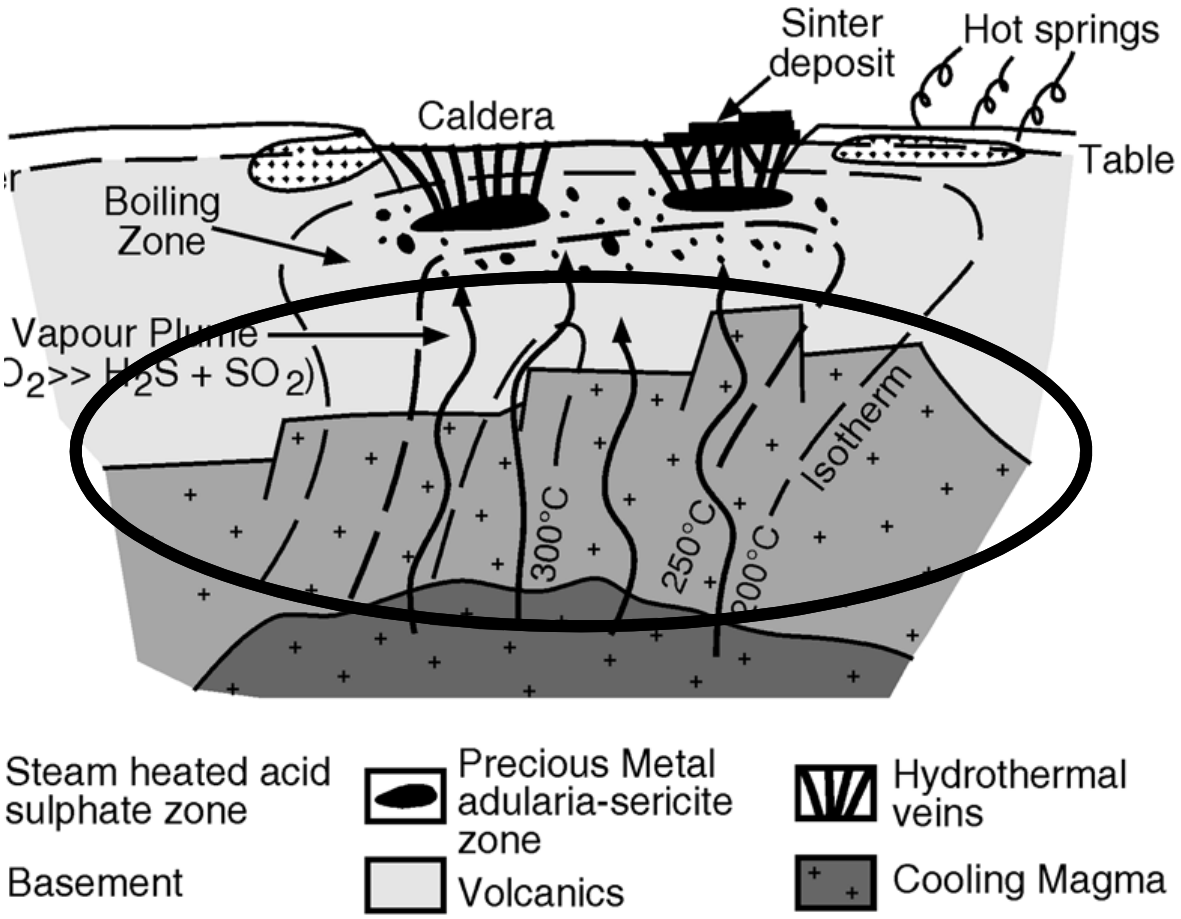

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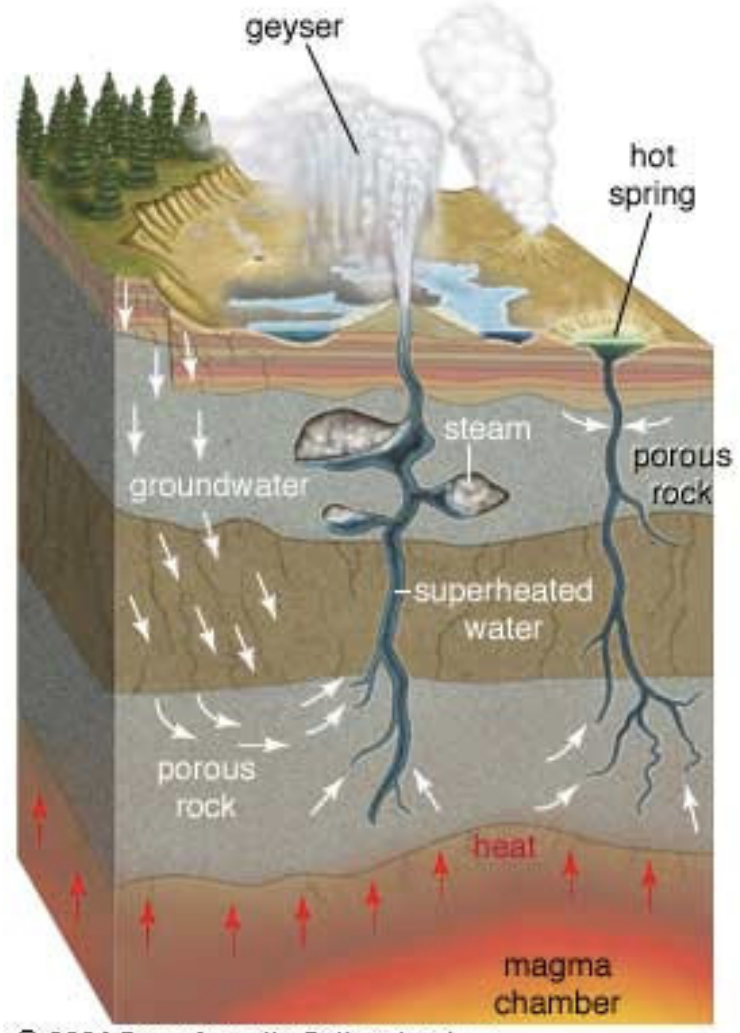
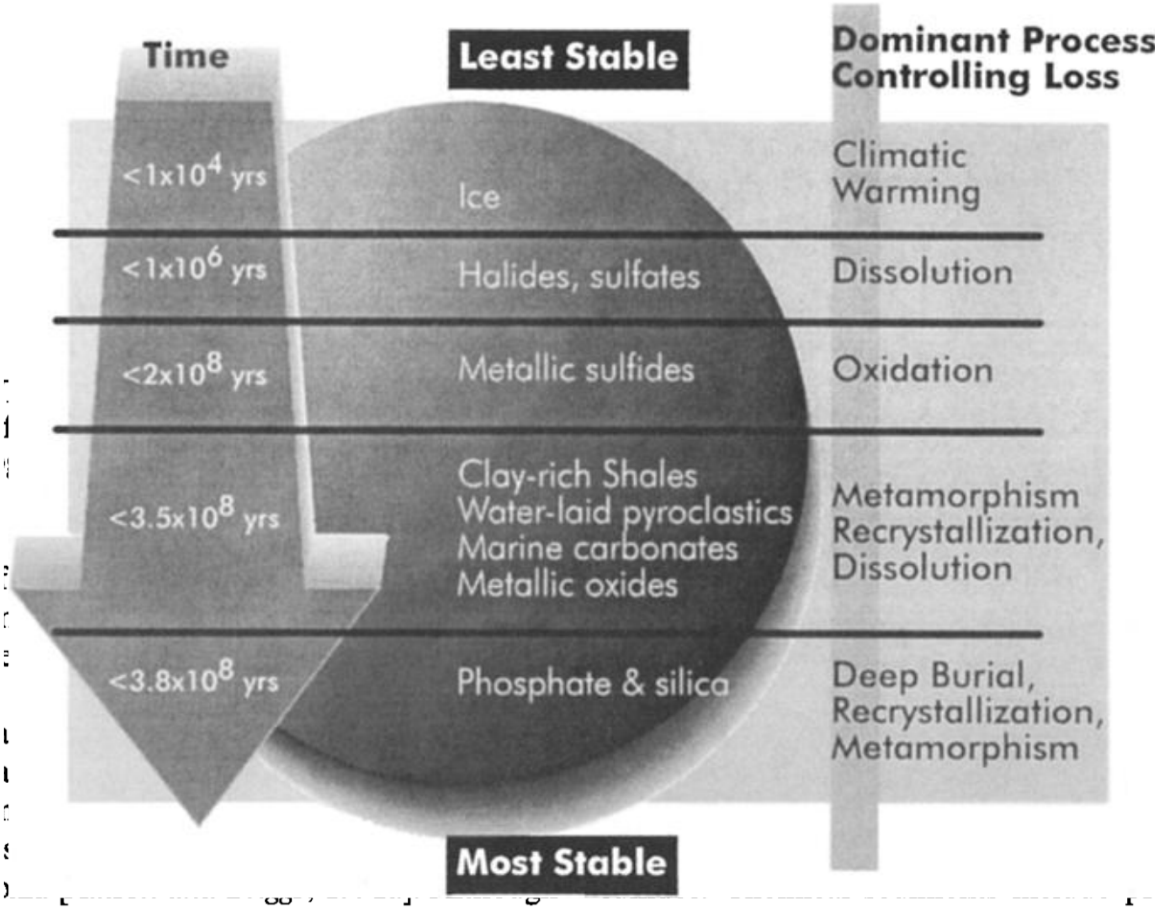
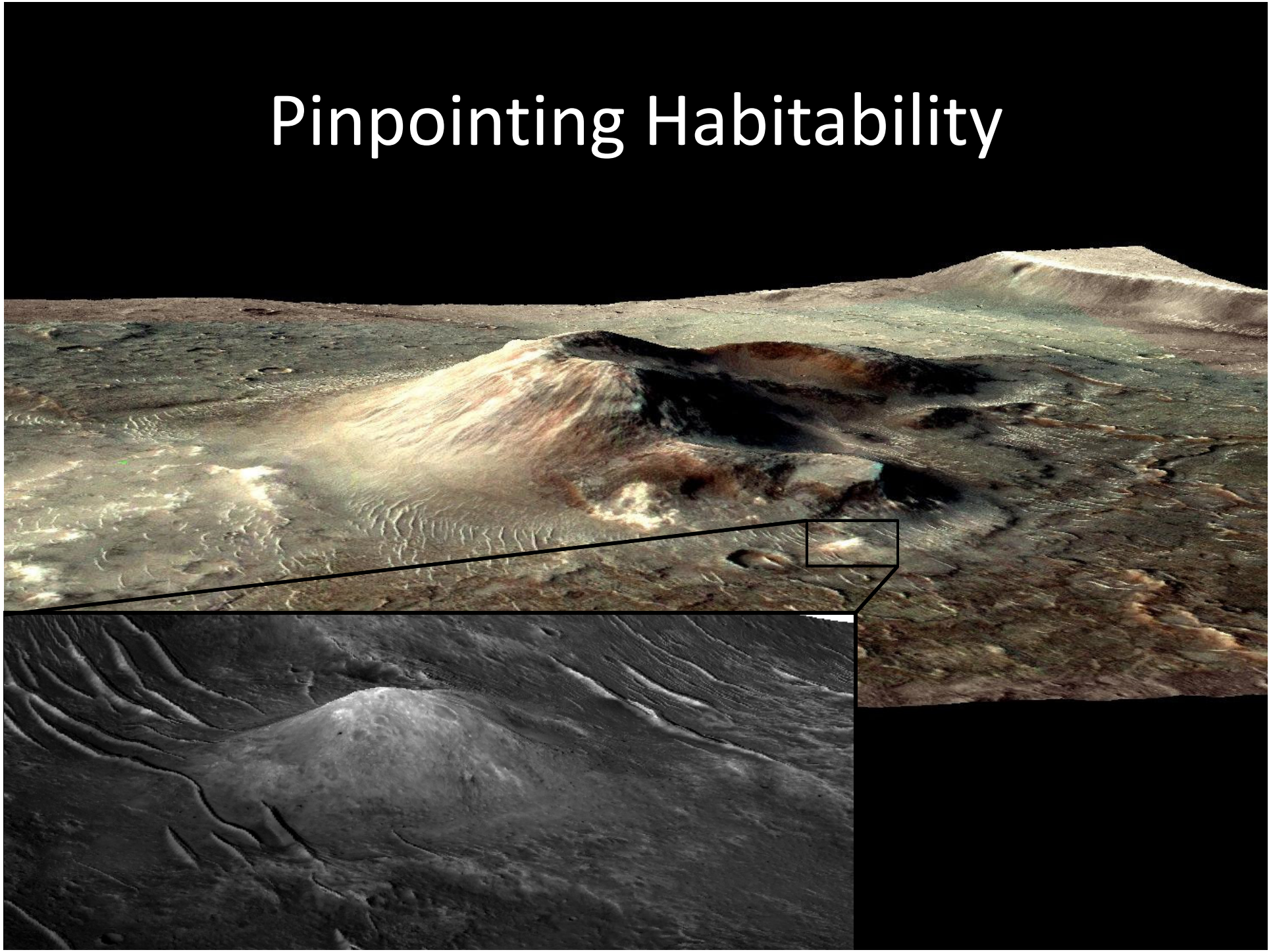
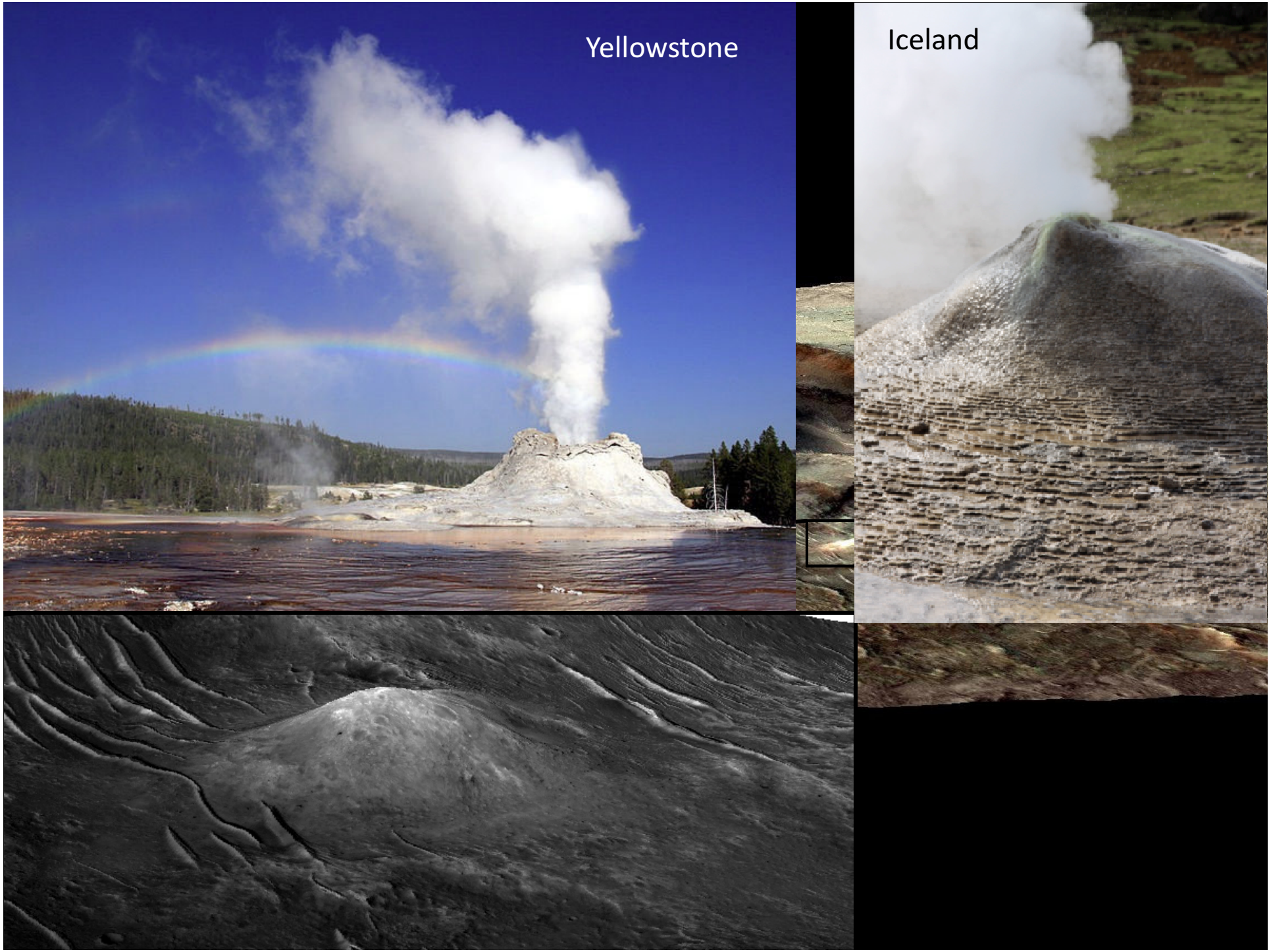




Farmer and Des Marais, 1999

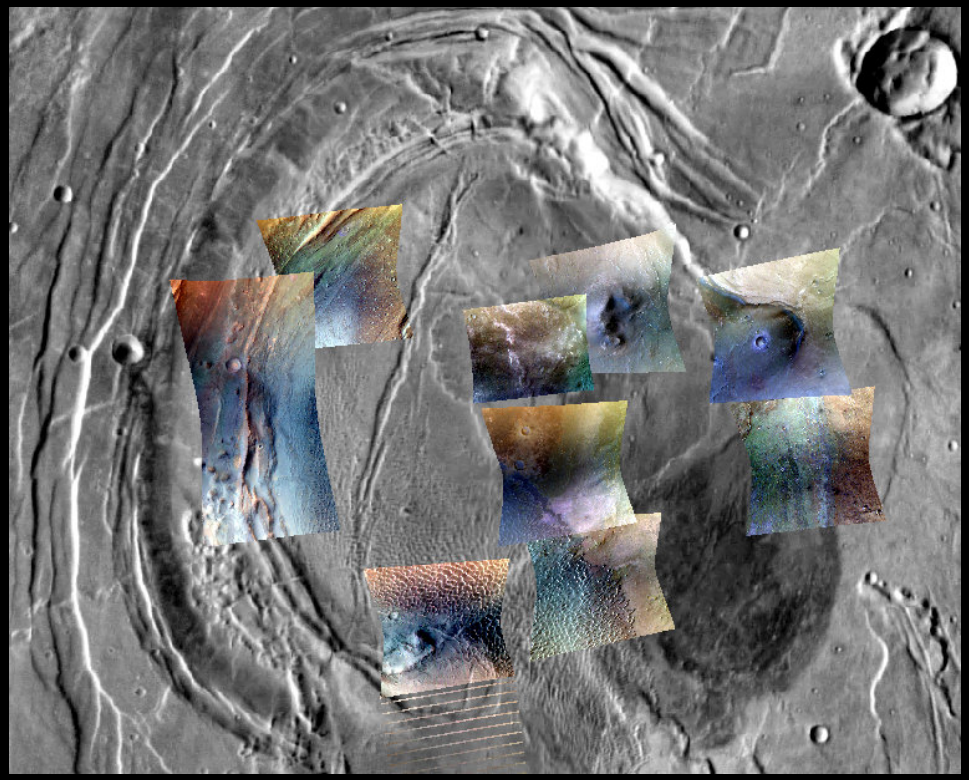
Pinpointing Habitability



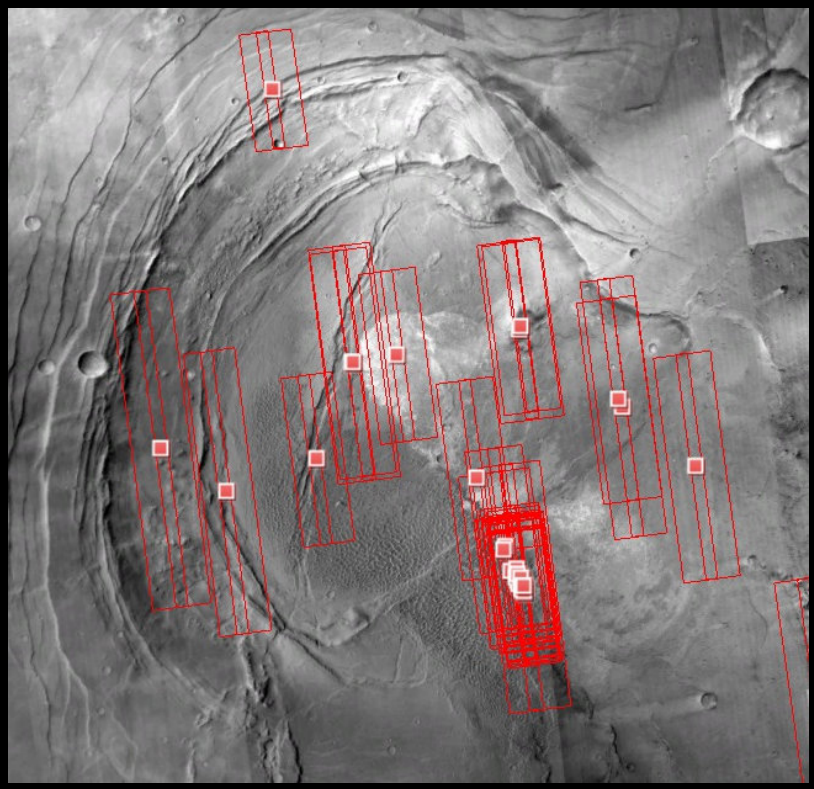

Yellowstone
Iceland

Hi-Res Landing Site Coverage

CRISM L-detector



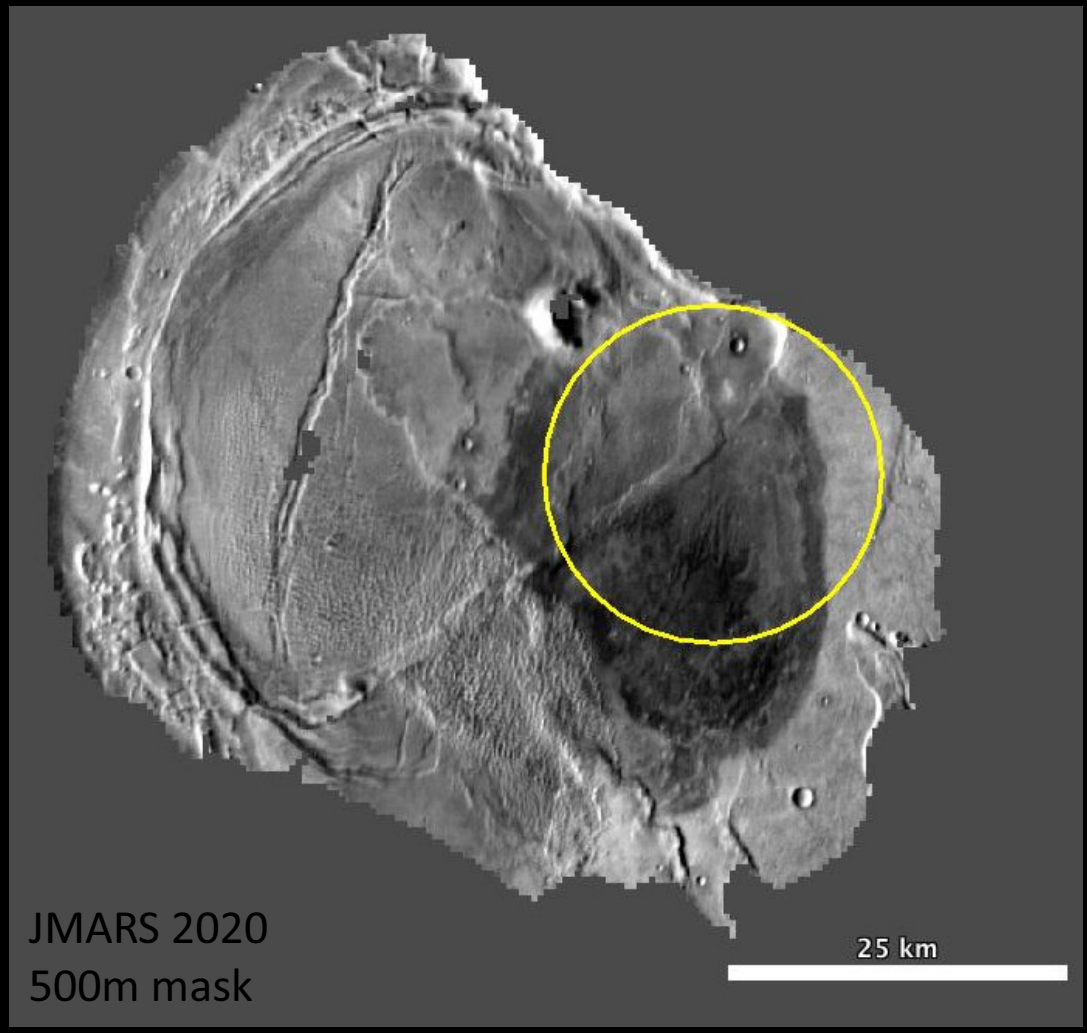
HiRISE



Landing Site Safety

- Location:
  - 9.07°N, 67.4°E
- Elevation
  - 475m-99m
  - Mean: 208m
  - Std. Dev.: 58m
- Slopes (CTX DEM)
  - Average: 2.52°
  - Std. Dev.:2.09°
- Terrain
  - Lava flows

500 m Elevation Mask



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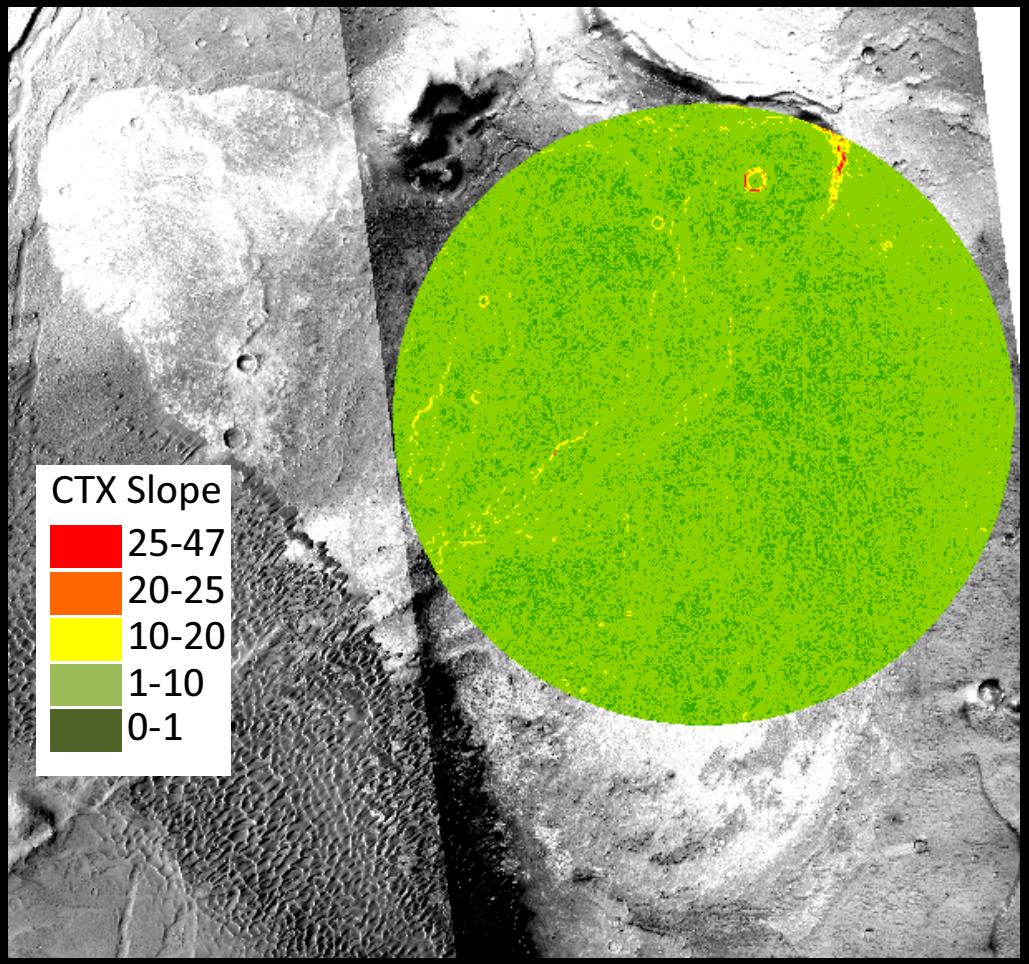
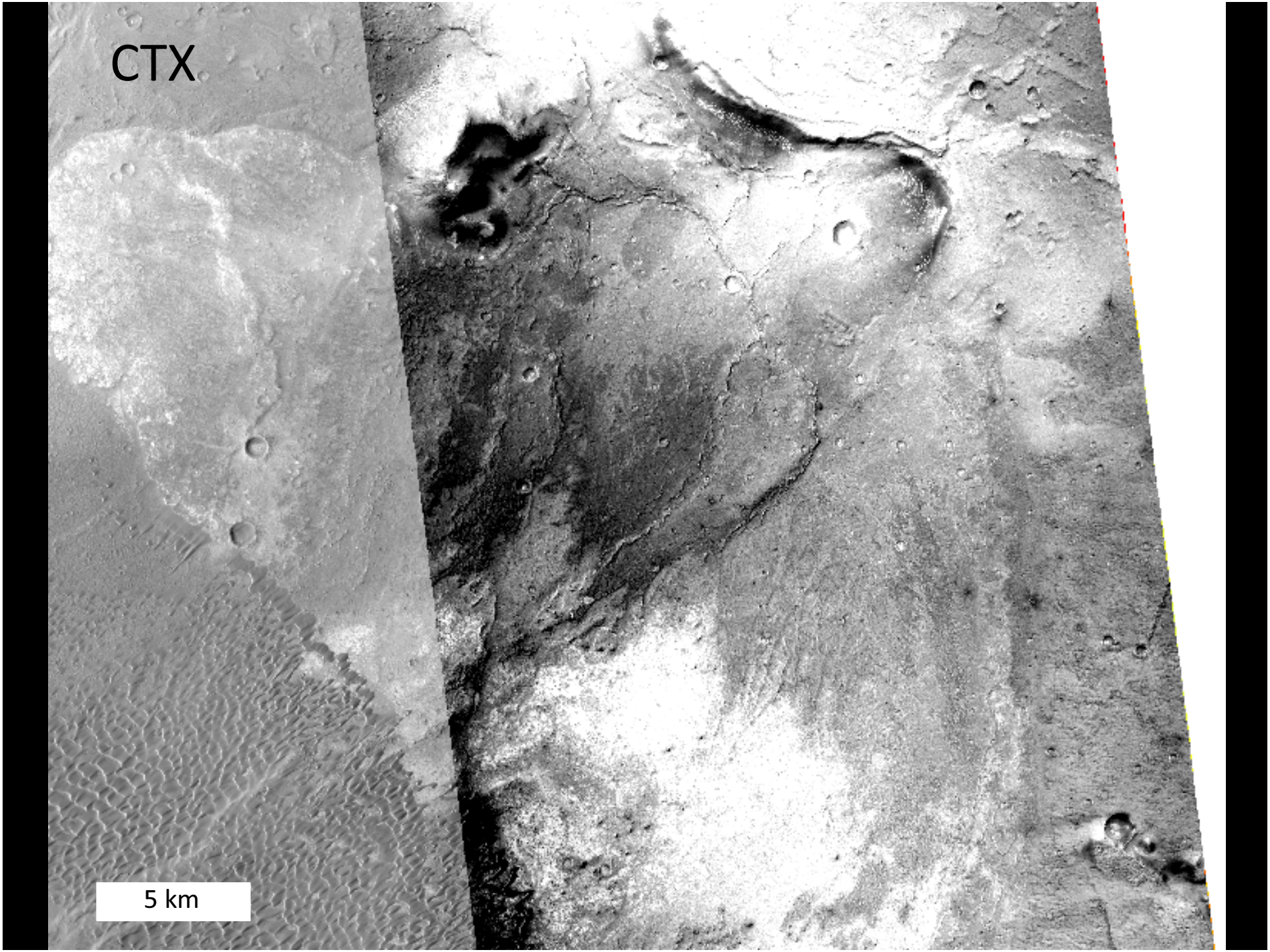
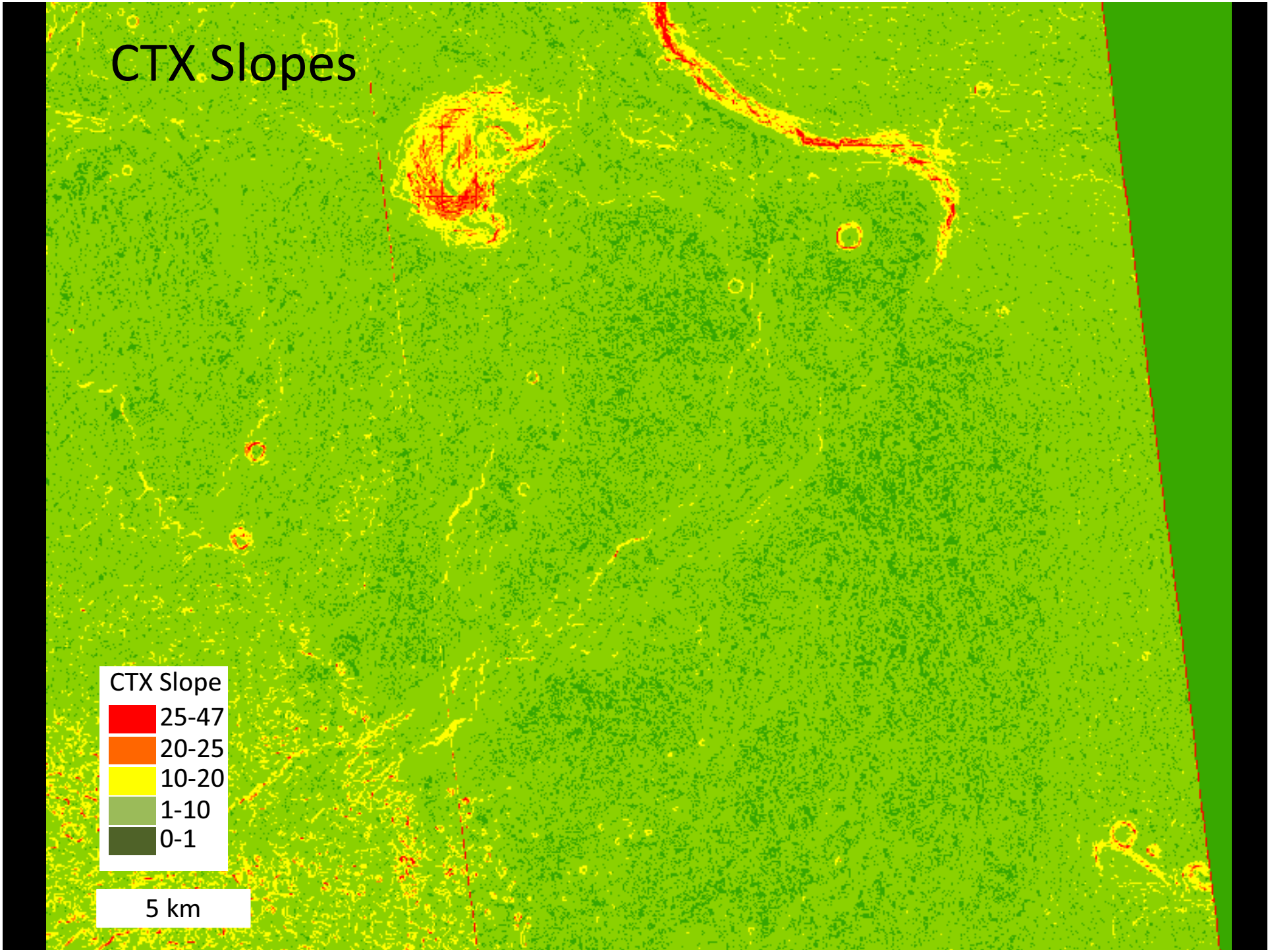
Landing Site CTX Slopes




CTX
5 km


CTX Slopes
CTX Slope
25-47
20-25
10-20
1-10
0-1
5 km

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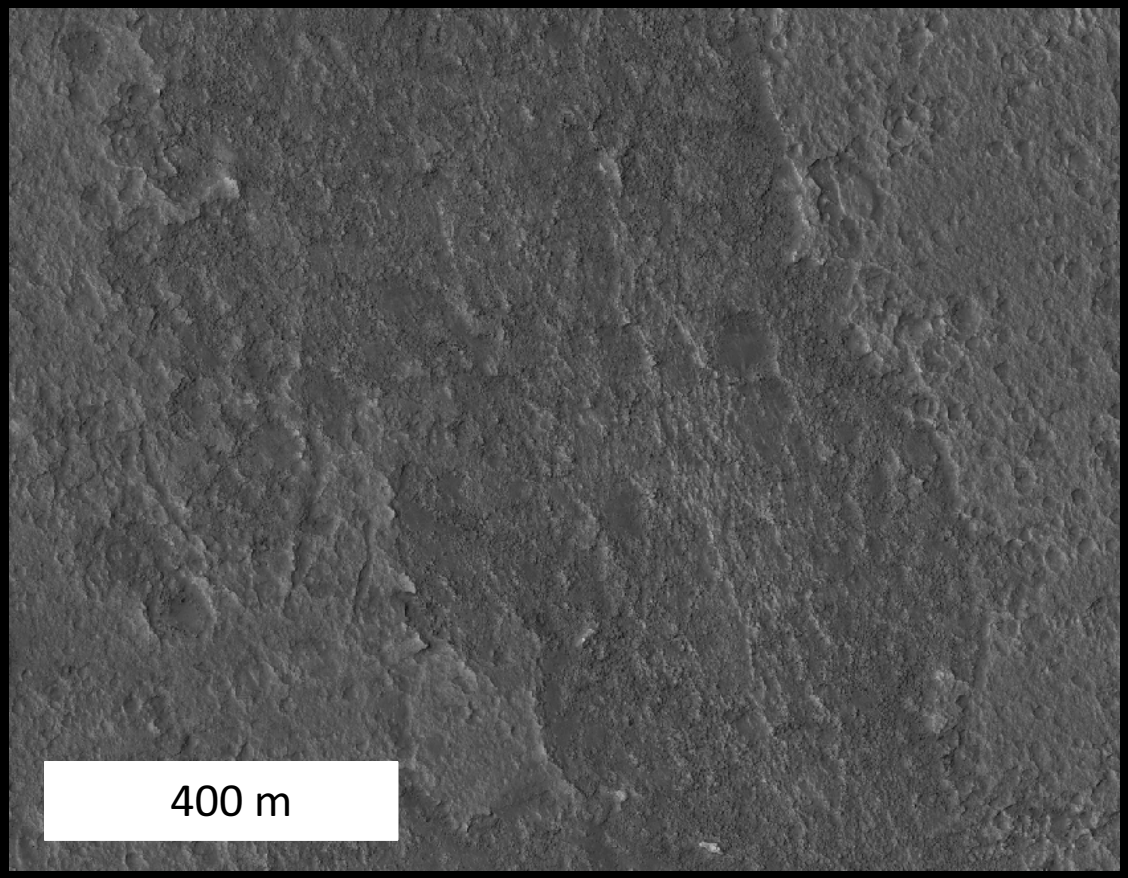
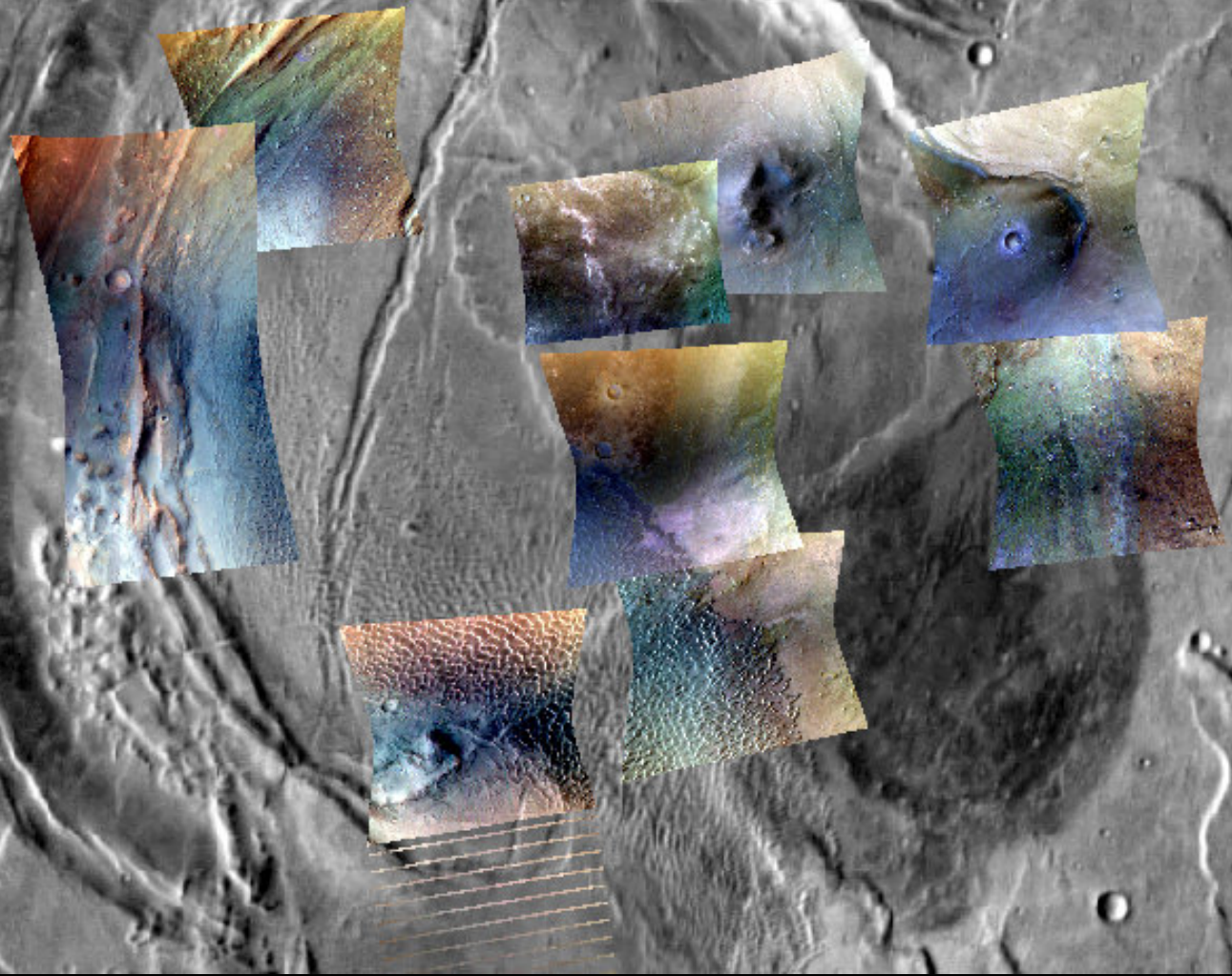
Sample HiRISE Landing Terrain

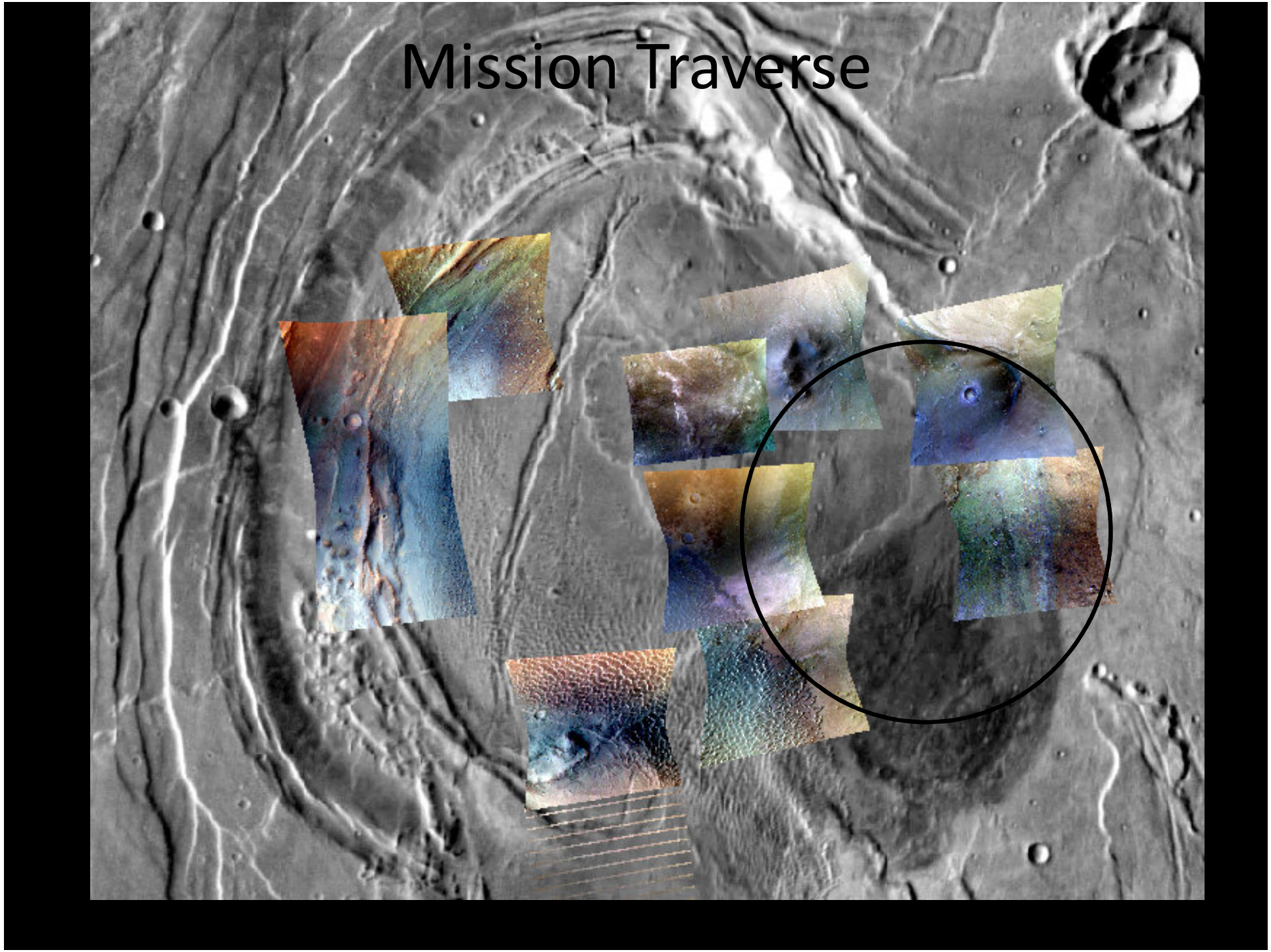


ESP_016905_1890

Mission Traverse



Mission Traverse



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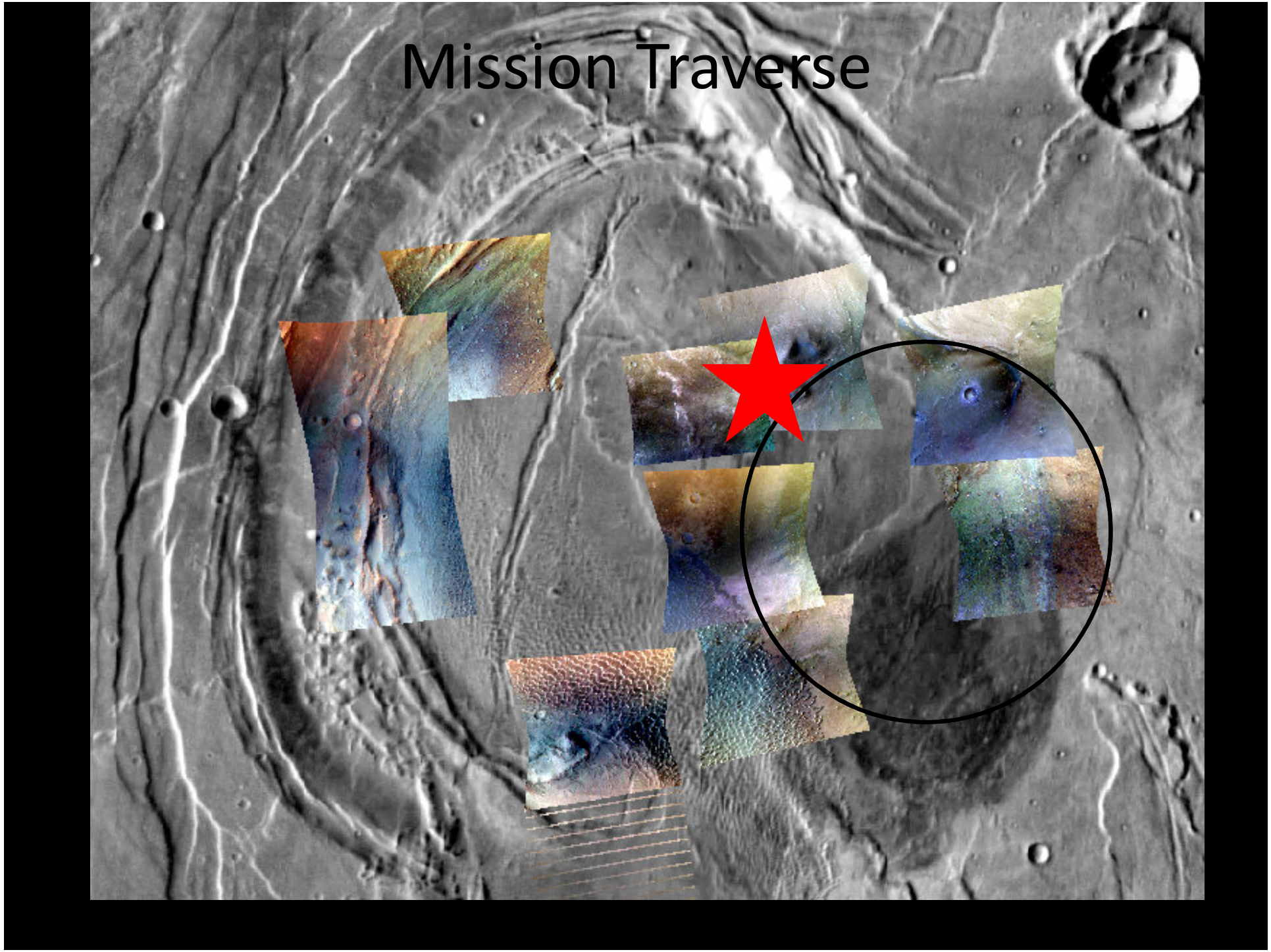
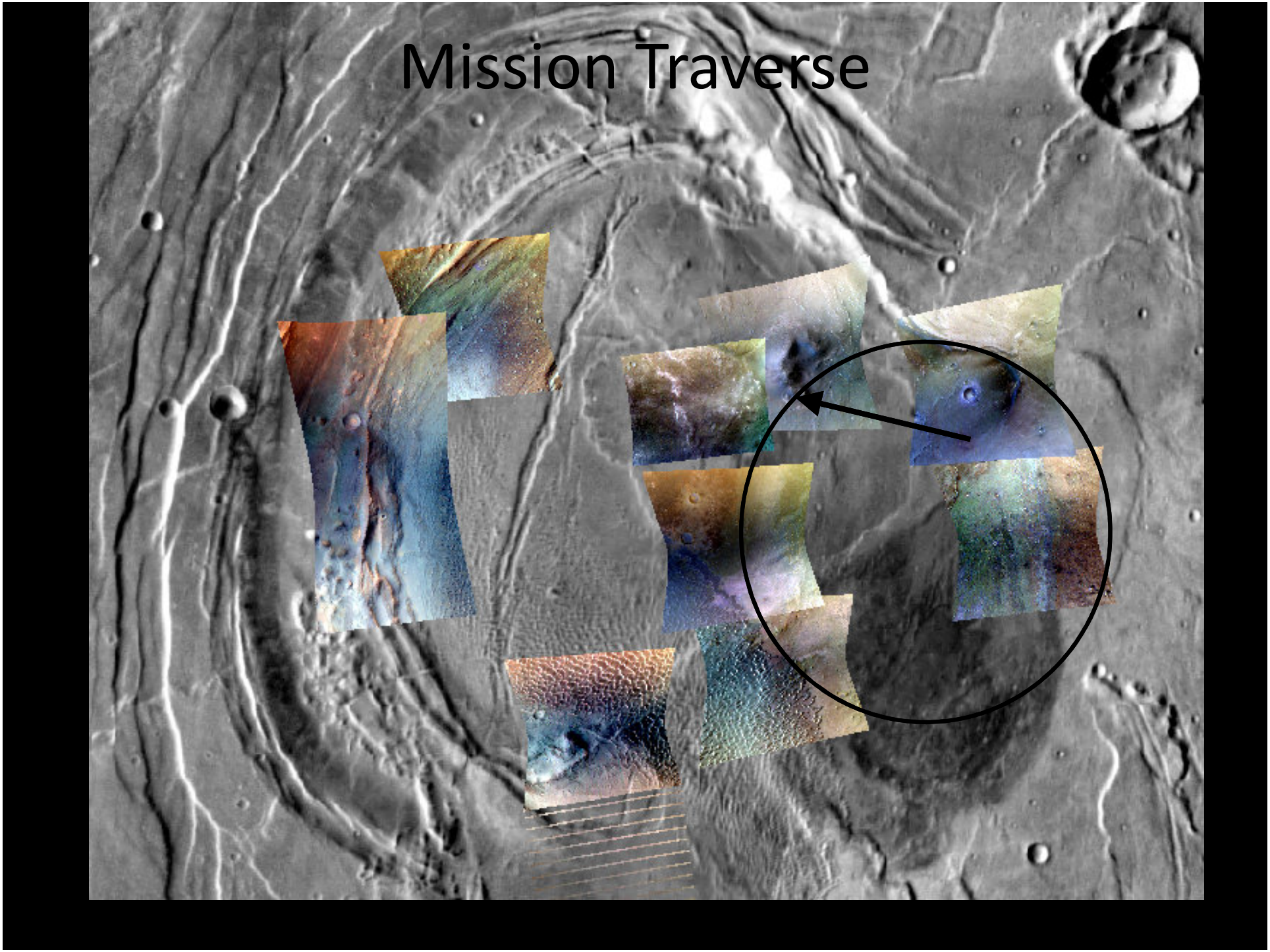
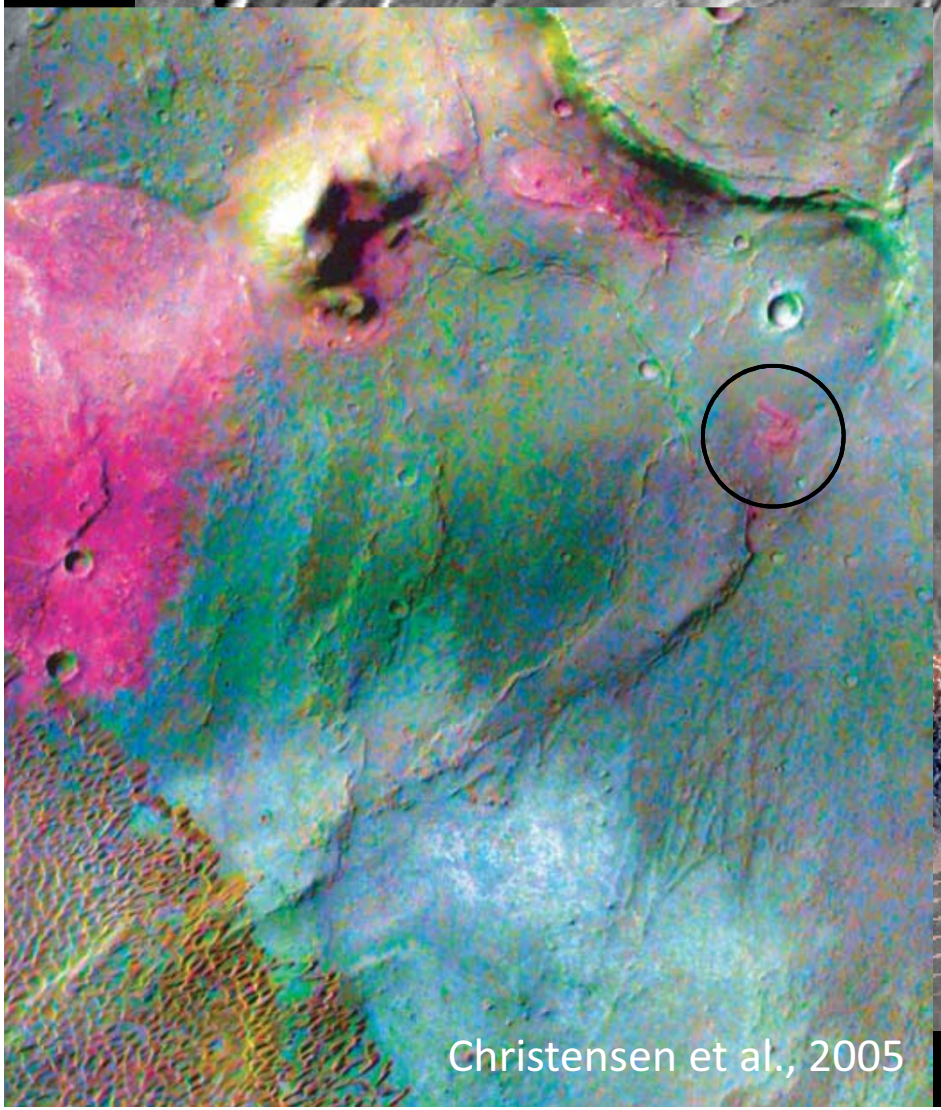


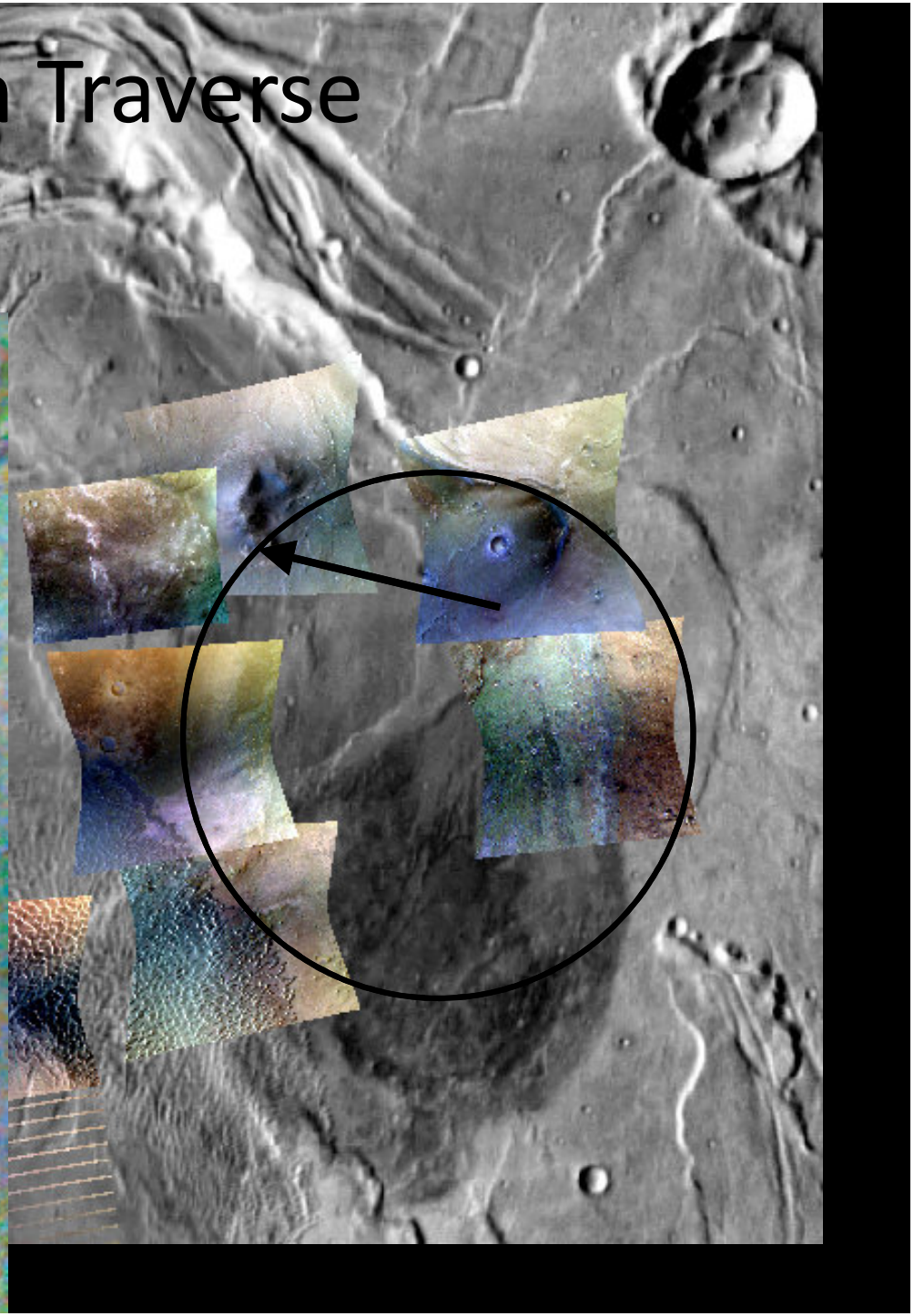
Mission Traverse



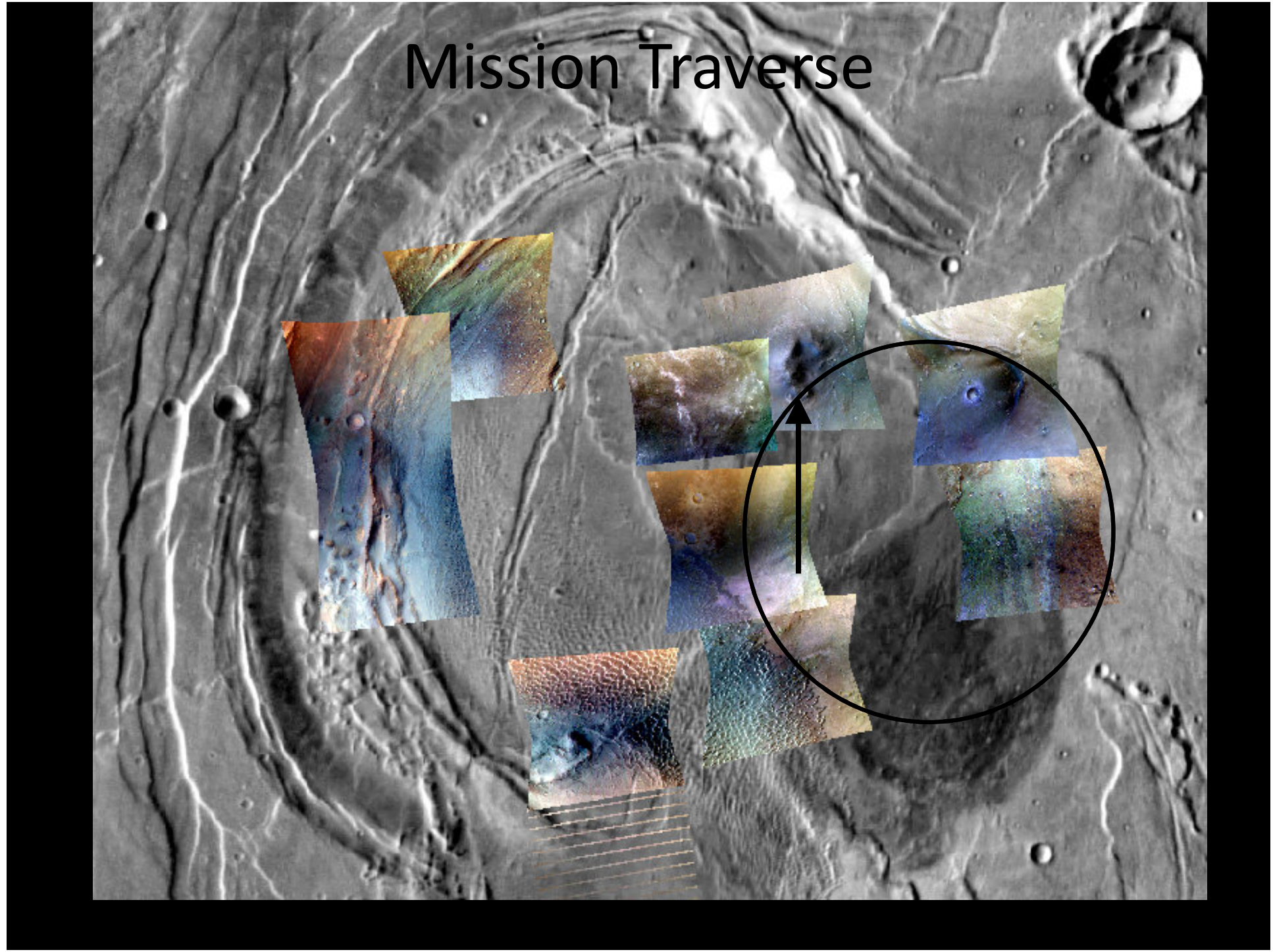
Mission Traverse

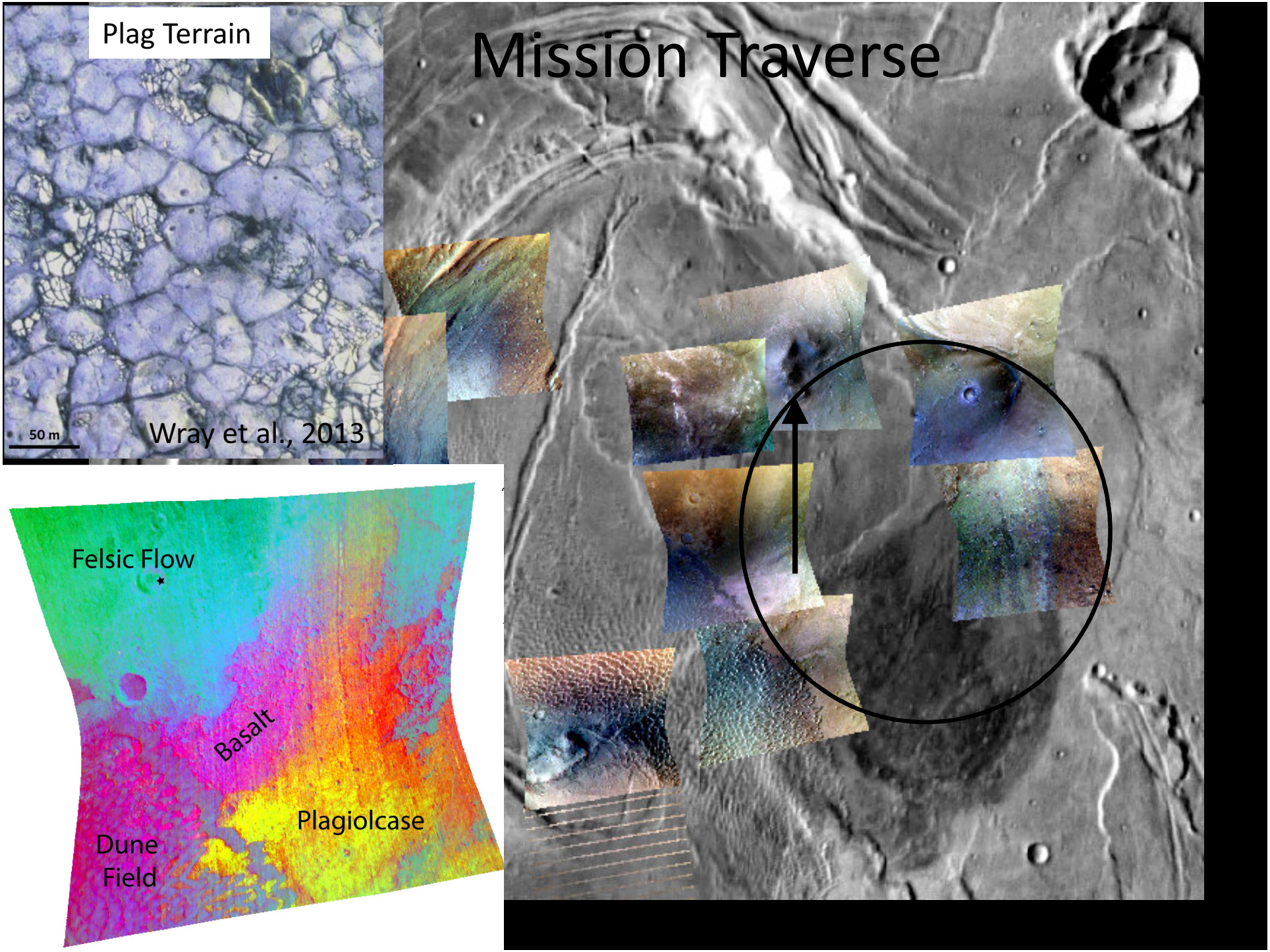


Christensen et al., 2005

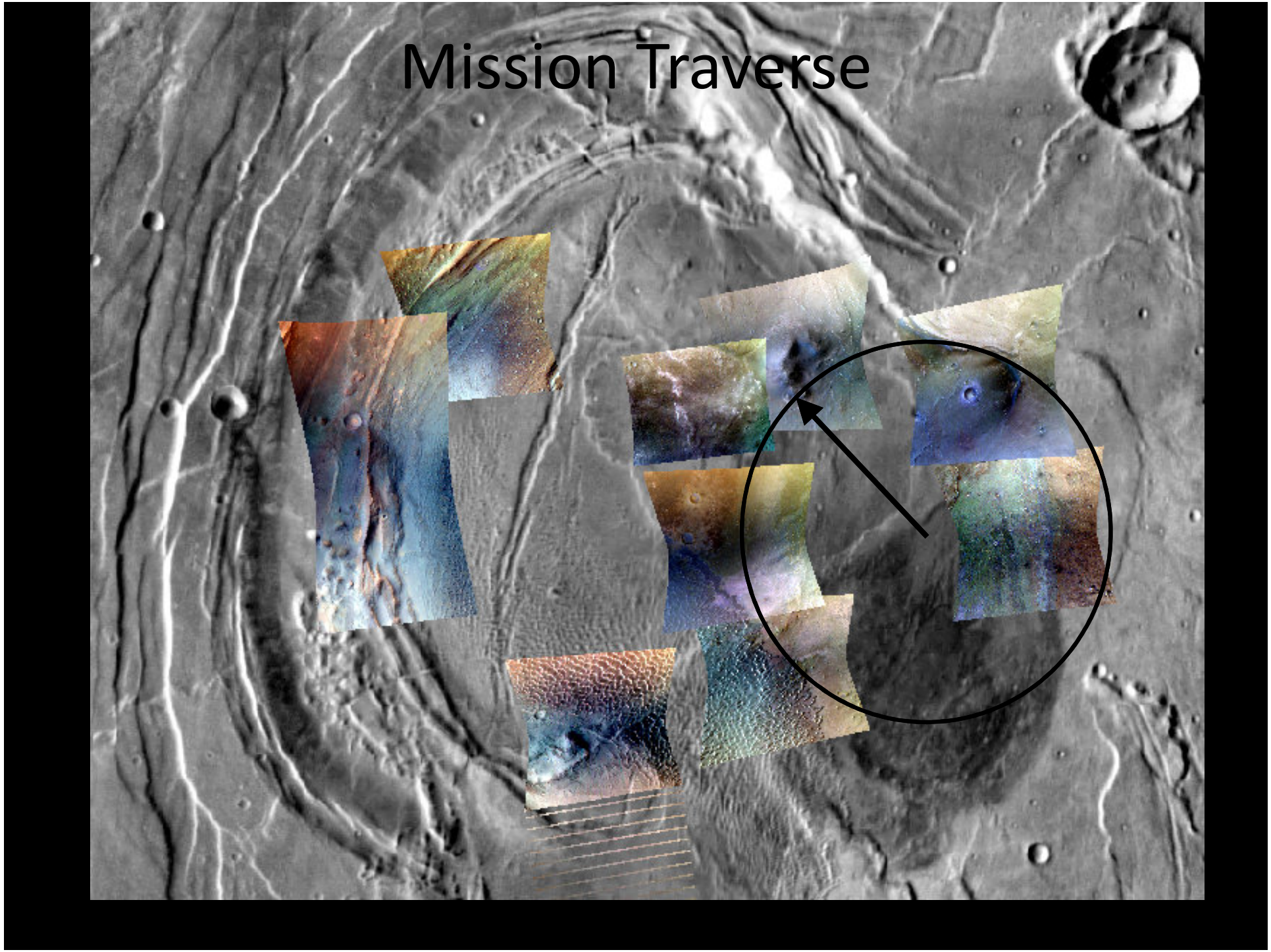


Mission Traverse




Plag Terrain
50 m
Wray et al., 2013
Mission Traverse
Felsic Flow
Basalt
Plagiolcase
Dune
Field

Mission Traverse



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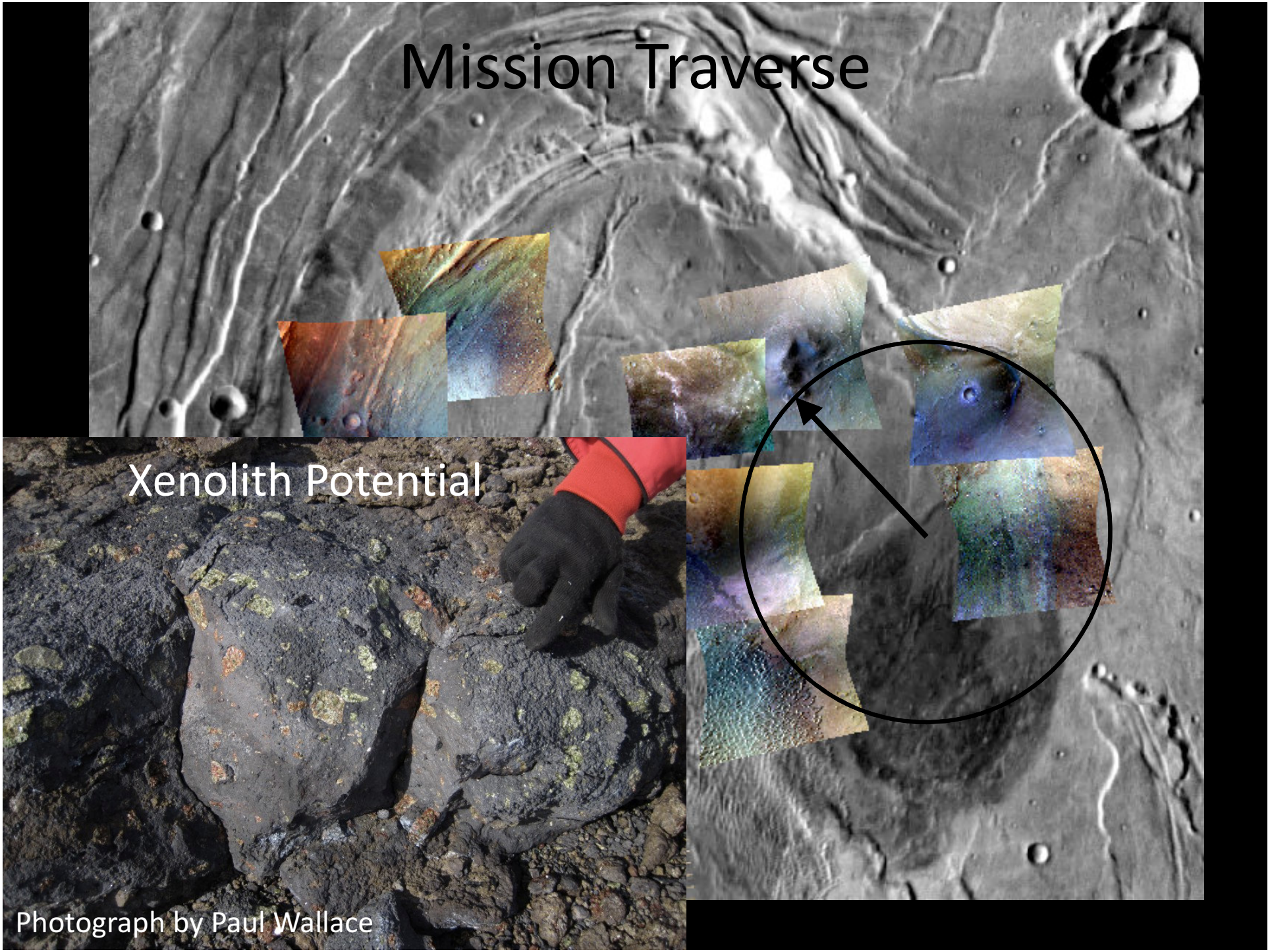
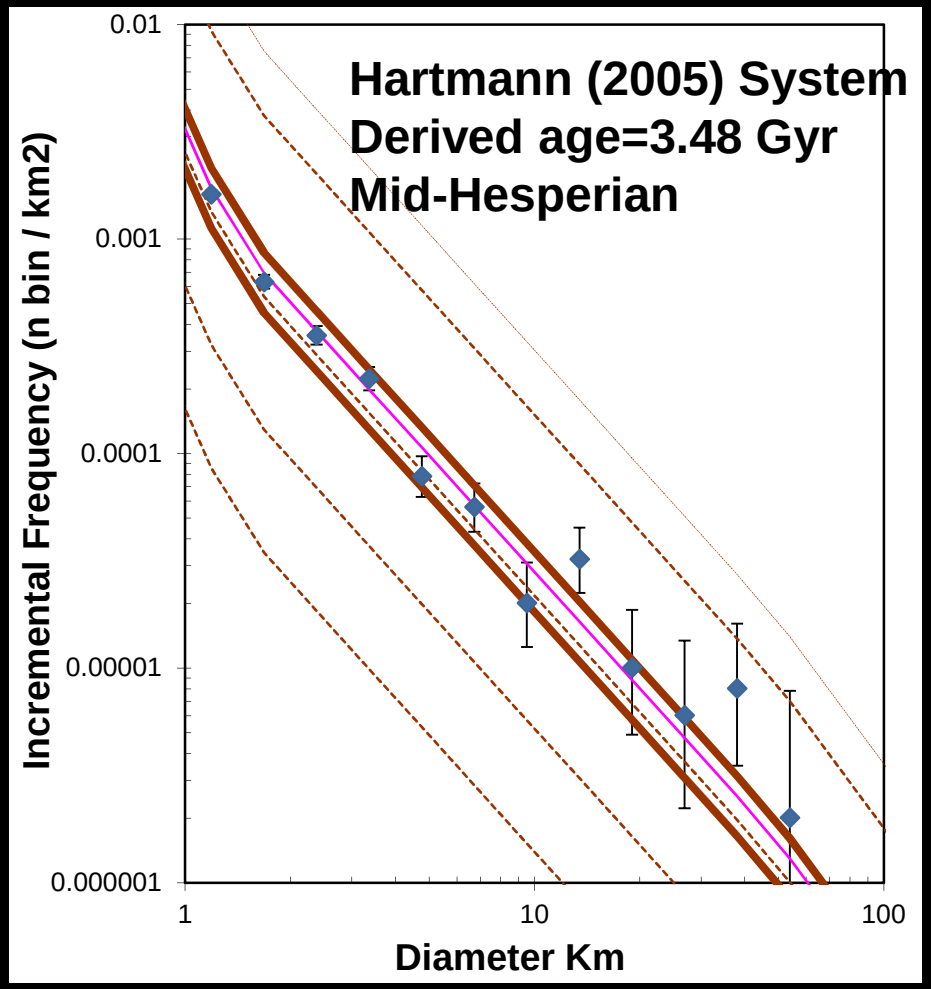
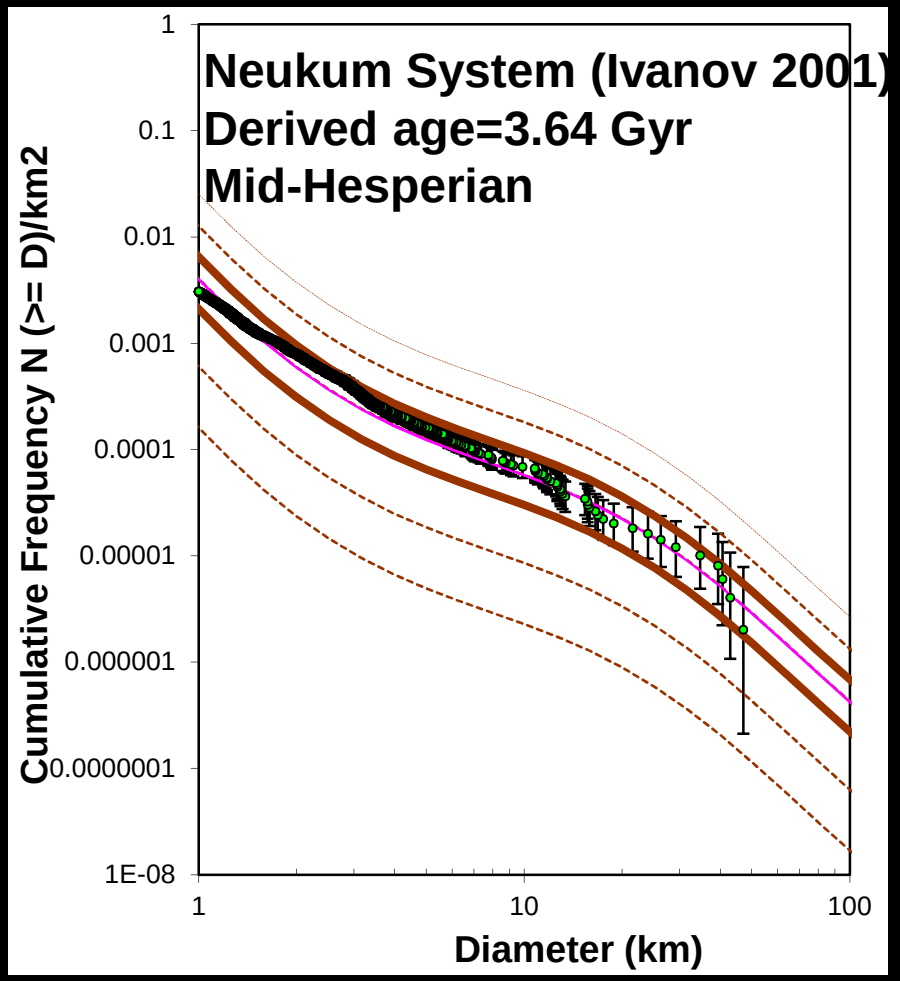


Calibrating Crater Statistics

- Syrtis/Nili Patera (400 km radius around caldera), N=1519
- Good statistics, broad area, but sufficiently large to not capture all resurfacing (i.e., younger 10-m flows) in some area.

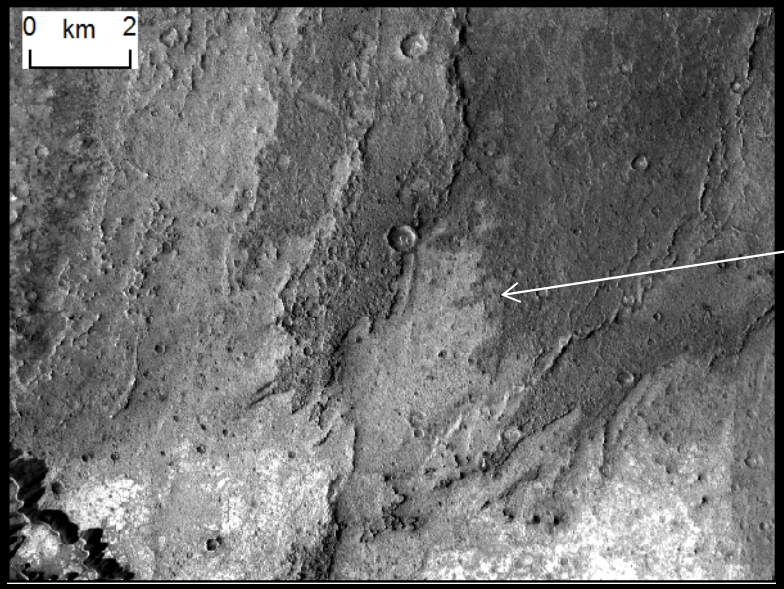




Data from Robbins and Hynek Catalog (checked for superposition)

Calibrating Crater Statistics

- At smaller scales: more diversity in age (e.g., individual flows from Early or Mid Amazonian).
- Over lifetime of mission, potentially could get multiple well-defined “age-frequency” pairs at different ages.



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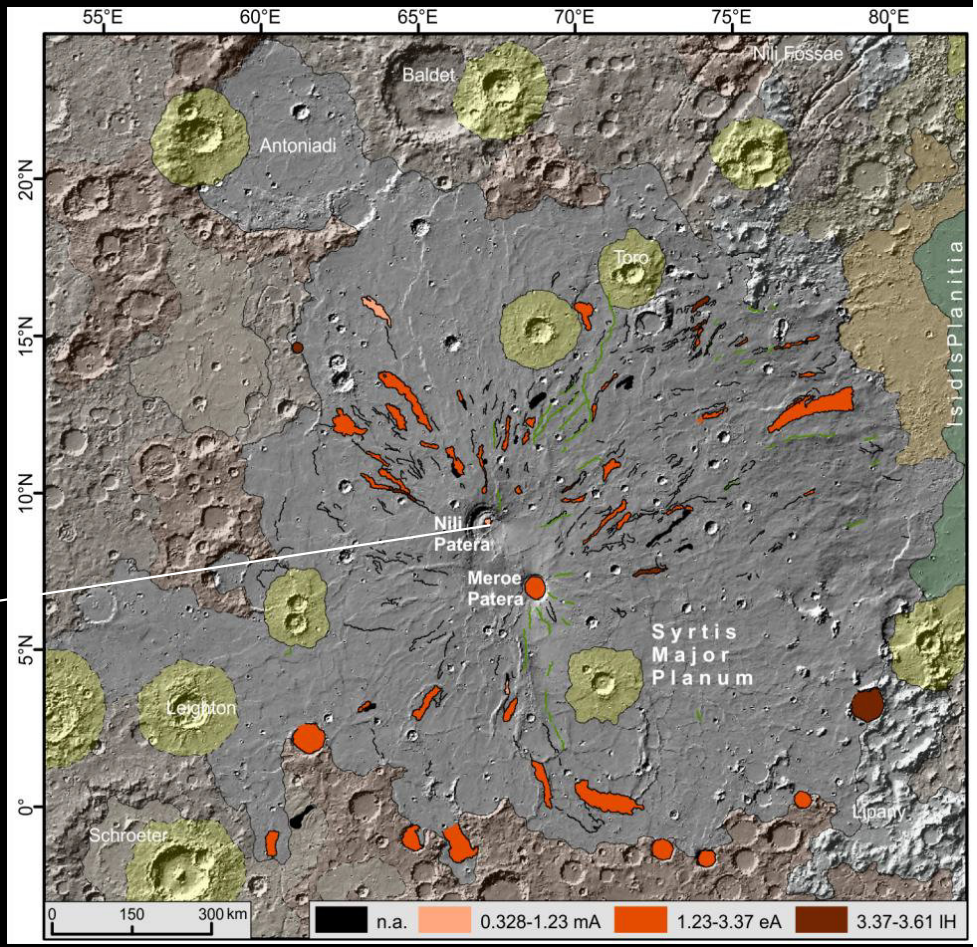
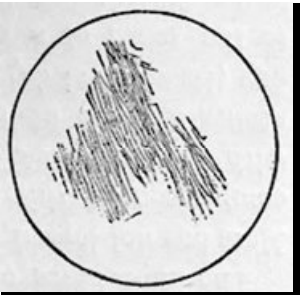
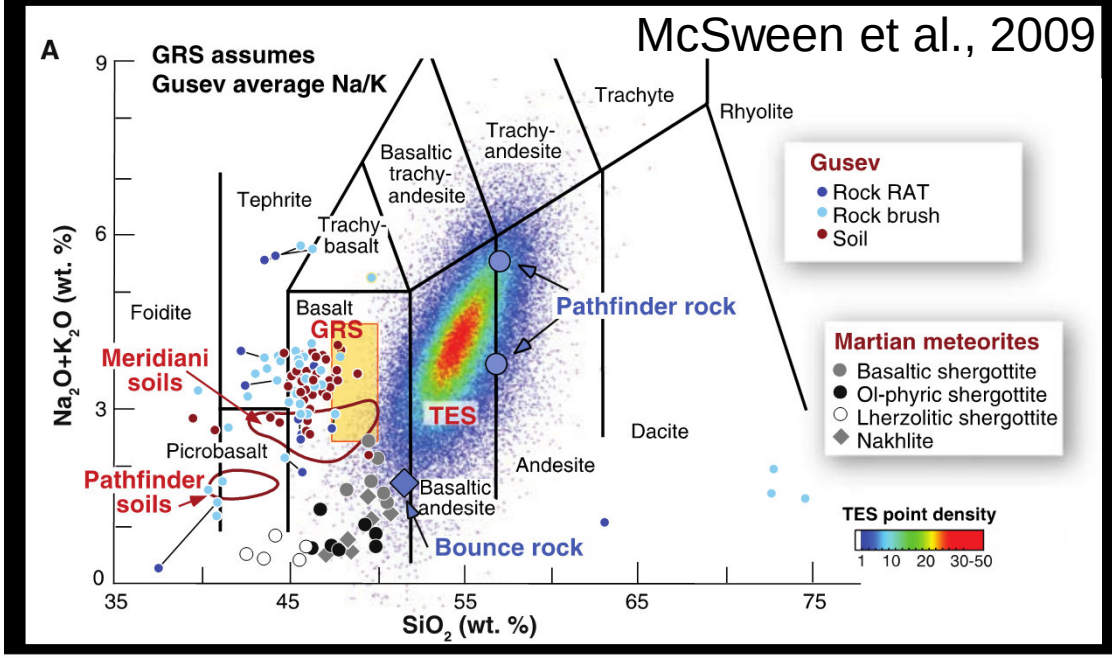
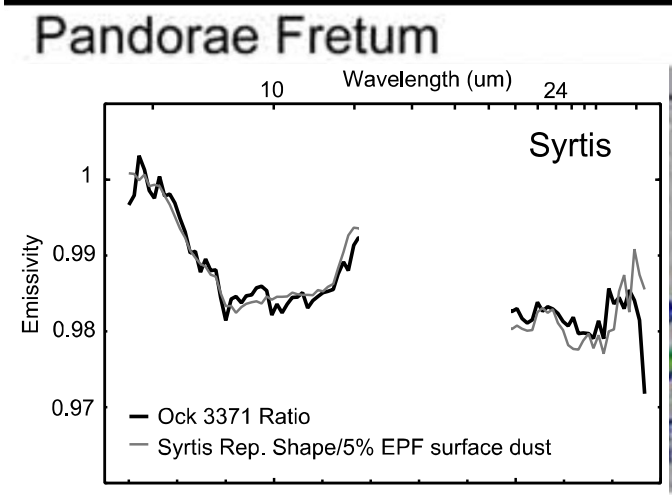


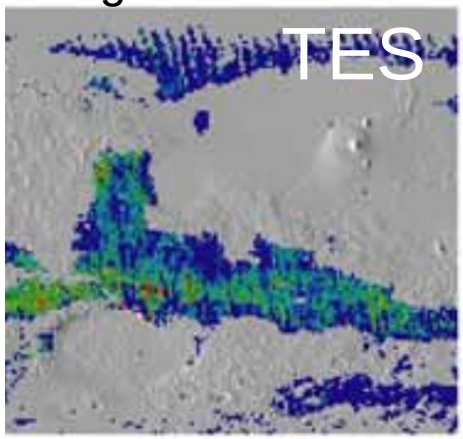
Platz et al., 2014

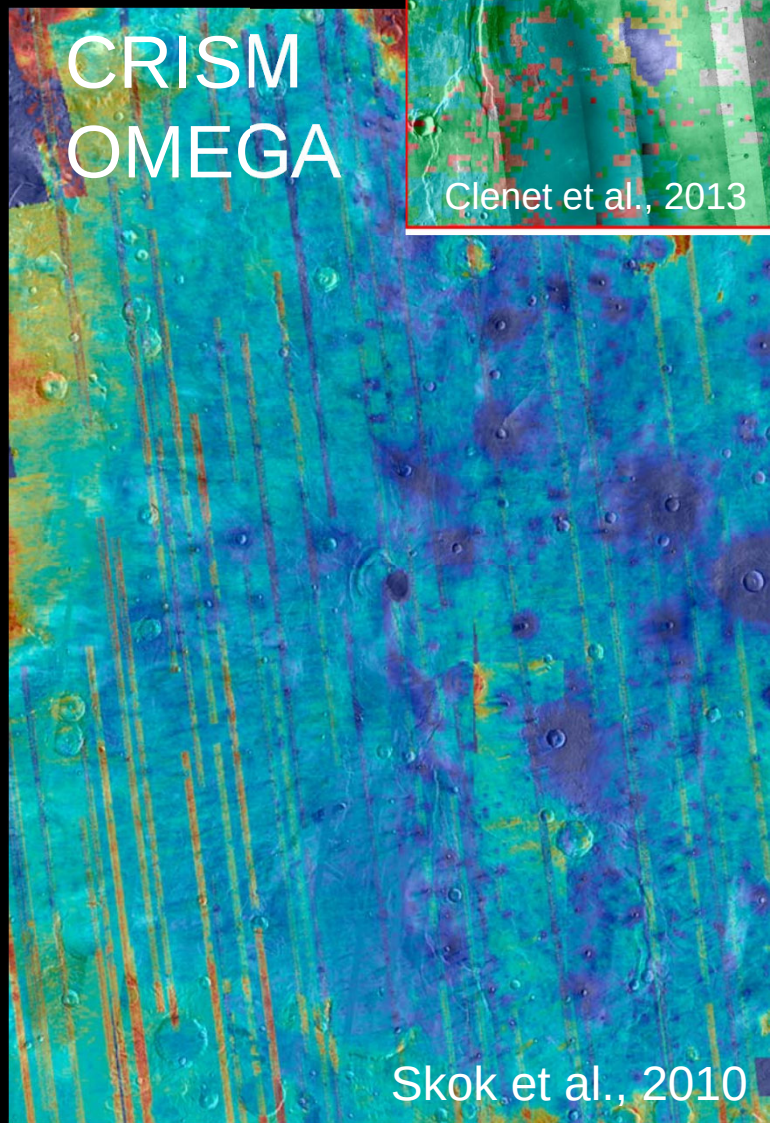


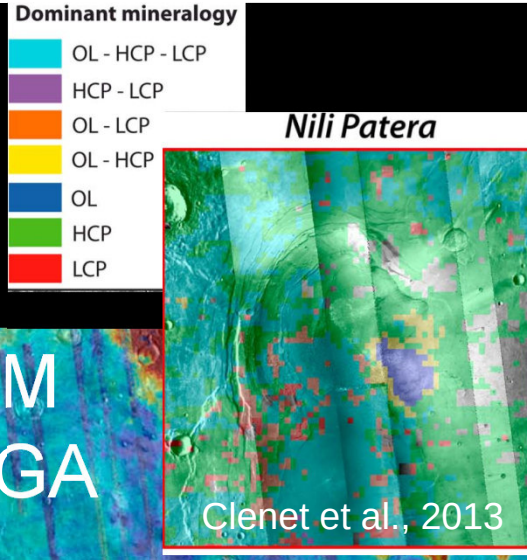
Spectral Confirmation











Science Objectives

- **Threshold Geological Criteria:**
  - ✓ Presence of hydrothermal sediments
  - ✓ Presence of aqueous phases in outcrop
  - ✓ Noachian/Early Hesperian age
  - ✓ Presence of igneous rocks
  - ✓ Not a Special Region
- **Potential Qualifying Geological Criteria:**
  - – Standing bodies of water and/or fluvial activity
  - ✓ Assemblages of secondary minerals of any age.
  - – Presence of former water ice, glacial activity or its deposits.
  - – Igneous rocks of Noachian age/megabreccia.
  - ✓ Volcanic unit of Hesperian or Amazonian
  - ✓ Probability of samples of opportunity
  - ✓ Potential for resources for future human mission

Reasons to Go

Science

- Hydrothermal system forms well-preserved silica mounds.
- Opportunity to sample **sub-surface**: Hydrothermal geochemistry and volcanic xenoliths.
- Evidence of evolved magmas and lavas.
- Syrtis Major volcanics are a key thermal and VNIR reference unit.
- Syrtis Major offers opportunity to calibrate crater dating.

Mars 2020

- Meets all main mission objectives and many secondary goals.
- Primary sampling target precisely known.
- Clear context supports quick caching.
- Minimal trafficability challenges.